AERONAUTICAL ENGINEERING REVIEW

MAY 1949

Flight Propulsion Issue

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Flying Douglas aircraft almost exclusively, Yankee crews have poured over half a million tons of supplies into Berlin since last June. This impressive feat has strained to the limit our resources in air transport. *It has shown why sufficient cargo planes must be considered essential to any modern military defense program.*

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Cover—McDonnell XF-88 Twin-Jet "Penetration" Fighter.

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AERONAUTICAL ENGINEERING REVIEW

Vol. 8 **MAY, 1949** **No. 5**

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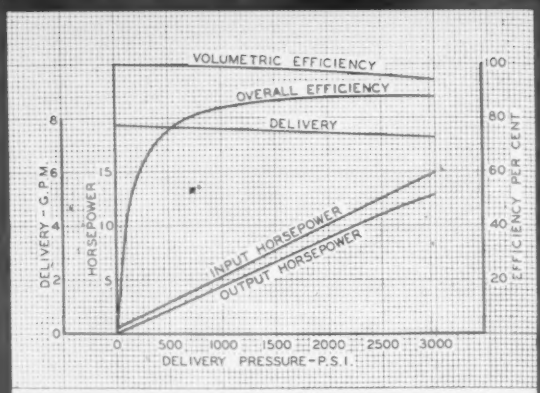

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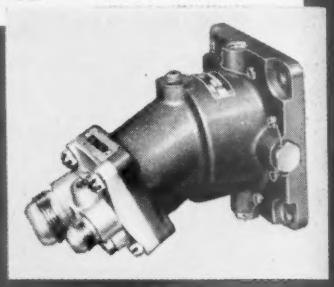
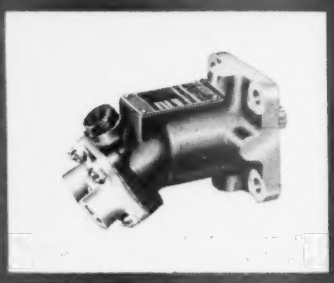


Vickers Model PF-3911 Series for 3000 psi



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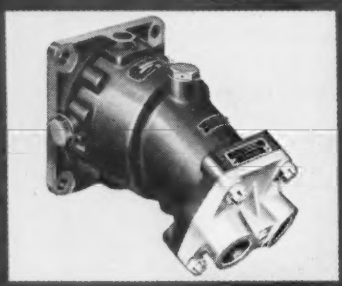

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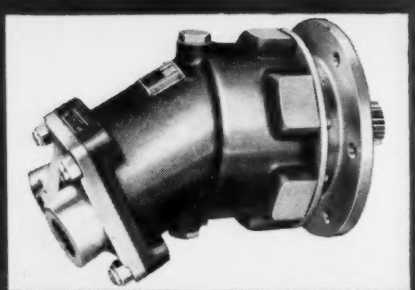
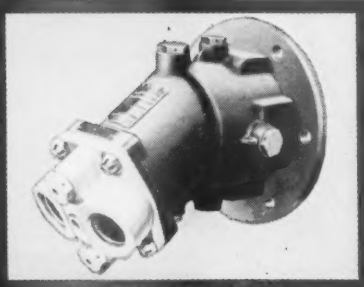
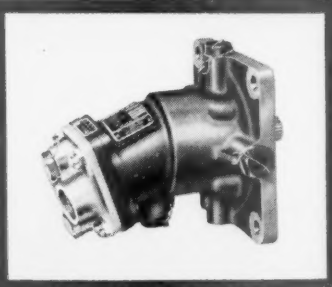


Vickers Model PF-3918 Series for 3000 psi



Vickers Model PF-3915 Series for 3000 psi



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I.A.S. News

A Record of People and Events of Interest to Institute Members

Handley Page to Speak at Joint Meeting Luncheon

Galaxy of Speakers at I.A.S.-R.Ae.S. Conference to Include Ted Wright, Grover Loening; Rentzel to Address Washington Section Dinner in Honor of British Guests.

SIR FREDERICK HANDLEY PAGE, eminent British aviation authority and Managing Director of Handley Page Ltd., an I.A.S. Honorary Fellow, will be the Institute's guest speaker at the Luncheon to be given on the final day of technical sessions of the I.A.S.-R.Ae.S. Joint Conference.

▸ **Opening Day**—On May 24, opening day of the technical sessions at the Astor, the Luncheon guest speaker is to be Honorary Fellow Dr. T. P. Wright, President of Cornell Research Foundation and recently appointed a full member of the National Advisory Committee for Aeronautics by the President.

He will be followed the next day, Wednesday, May 25, by Grover Loening, who is Consultant to the National Advisory Committee for Aeronautics, Washington, D.C.

When our British guests reach Washington, to which they will be flown by American Airlines after inspecting American's maintenance line at La Guardia Field on May 31, they will be given a dinner by the Washington Section, headed by Chairman Milton B. Ames. The chief speaker at this affair will be Civil Aeronautics Administrator Delos Rentzel.

A recapitulation of the technical papers to be read at the Astor Joint Conference, together with the dates and time of delivery, is given as follows:

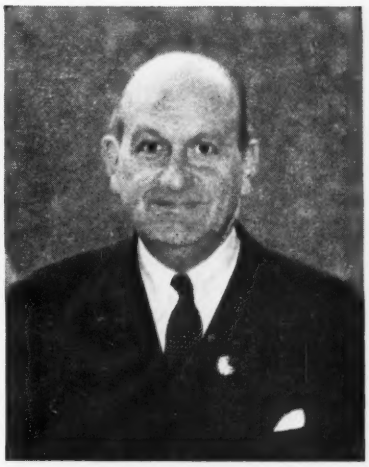
• **Tuesday A.M., May 24**—"The Propeller Gas Turbine in Service," F. M. Owner, Chief Engineer (Engines), Bristol Aeroplane Company Ltd.; "Optimum Fields of Applications for Air-Consuming Aircraft Power Plants," W. G. Lundquist, Chief Engineer, Wright Aeronautical Corporation; "Recent Design Refinements in Turbojet Engines," N. Burgess and J. C. Buechel, Aircraft Gas Turbine Division, General Electric Company.

• **Tuesday P.M., May 24**—"Turbine-Engined Transport Aircraft," G. R. Edwards, Chief Designer, Vickers-Armstrongs Ltd.; "Research on Helicopters at the R.A.E. with Special Reference to the Stability of Multi-Rotor Helicopters," H. B. Squire, Aerodynamics Department, Royal Aircraft Establishment; "Operational Experience with Helicopters," Clarence M. Belinn, President, Los Angeles Airways, Inc.

• **Wednesday A.M., May 25**—"Aircraft Materials from the Designers' Point of View," A. E. Russell, Chief Designer (Aircraft), Bristol Aeroplane Company Ltd.; "The Application of Materials from the Manufacturers' Point of View," P. L. Teed, Deputy Chief of Aeronautical Research & Development, Vickers-Armstrongs Ltd.; "Materials in the Aircraft Industry," Clyde Williams, Director, Battelle Memorial Institute.

• **Wednesday P.M., May 25**—"Aeroelastic Problems at Supersonic Speeds," A. H. Flax, Assistant Head, Aero-Mechanics Department, Cornell Aeronautical Laboratory, Inc; "The Life of Aircraft Structures," H. A. Wills, Council for Scientific and Industrial Research, Australia; "American Structural Design Trends," G. G. Green, Chief Structures Engineer, Consolidated Vultee Aircraft Corporation.

• **Wednesday Evening, May 25**—"The Relative Merits of Auxiliary Power Systems—The Hydraulic Aspect," H. G. Conway, Technical Director, British Messier Ltd.; "The Electrical Aspect," R. H. Woodall, Chief Engineer, Rotax Ltd.; "The Pneumatic Aspect," H. R. Haerle, Chief Technician, The Hymatic Engineering Company, Ltd.; "Aerodynamically Boosted Surface Controls as Applied to the DC-6 Transport," Orville R. Dunn, Douglas Aircraft Company, Inc.



Sir Frederick Handley Page.

• **Thursday A.M., May 26**—"Comparison Between Theory and Experiment for Wings at Supersonic Speeds," Walter Vincenti, Ames Aeronautical Laboratory, N.A.C.A.; "Some Considerations of the Flutter Problems of High-Speed Aircraft," E. G. Broadbent, Structures Dept., Royal Aircraft Establishment; "Flight Research at Transonic and Supersonic Speeds with Free-Falling and Rocket-Propelled Models," Floyd L. Thompson, Chief of Research, Langley Aeronautical Laboratory, N.A.C.A.

• **Thursday P.M., May 26**—"The Relative Efficiencies of Large Landplanes and Flying Boats," D. Keith-Lucas, Chief Designer, Short Brothers & Harland Ltd.; "Aerodynamic Efficiencies of Large Landplanes," G. S. Schairer, Staff Engineer, Boeing Airplane Company; "Operating Factors Affecting the Design of Future Civil Transport Aircraft," Christopher Dykes, Deputy Chief Project Engineer, British Overseas Airways Corporation; "The Utilization Factors and Maintenance of Civil Airplanes," Warren Alberts, United Air Lines, Inc.

Fourth Annual Flight Propulsion Meeting

Luncheon, Exhibitors' Displays, and Reception Add Interest to Propulsion Meeting

THE MORE THAN 500 engineers who attended the Fourth Annual Flight Propulsion Meeting in Cleveland on March 18 were treated to several innovations that added greatly to their enjoyment and the success of the meeting. Static displays by seven of the local manufacturers and a reception for the dinner guests and friends of these companies provided a natural stage setting for informal gatherings and discussions between technical sessions.

Much credit for the arrangements and smooth-flowing operation of the entire meeting is due the officers of the I.A.S Cleveland Section and Dr. Sharp's staff at N.A.C.A.'s Lewis Flight Propulsion Laboratory.

▸ **Collier Trophy Winner Speaks**—Luncheon guests, who came from all parts of the country and Canada, heard John Stack make a strong and logical plea for a closer coordination of functions between the research, manufacturing, and military organizations. He cited the development of the Bell XS-1 as proof of the outstanding progress that can be made when all three groups combine their efforts to achieve one specific objective.

Mr. Stack also stressed the fact that aeronautical research brings forth developments that have applications in fields other than aviation. The high-compression engines used in automobiles today, as well as the quality of gasoline now available to motorists, are but several typical examples in a long line of modern products that stem directly from original aeronautical research, he pointed out.

▸ **Exhibitors' Show**—The static displays provided by seven Cleveland companies drew an unusual amount of interest from such a supposedly hardened group of aeronautical engineers. Despite the hardships of being confined to a small 10- by 10-ft. space and the necessity of completely setting up each exhibit in the 2 hours preceding the opening of technical sessions, the exhibitors did a remarkable job. This is evidenced by the numerous comments overheard at the meeting and the photographs of the displays shown on the opposite page.

▸ **Technical Sessions**—For the first time in the history of these I.A.S. Propulsion Meetings, the reciprocating engine was completely relegated to the background. The theme of the entire show was "jets and more jets." Security restrictions prevented the open discussion of more recent developments, but the eleven papers presented covered many aspects of the common problems and unclassified improvements.

A complete coverage of the technical sessions will be found on page 26 of this issue. Preprints of the papers available are listed on page 53.

(*Top row, left to right*) John Stack, 1948 Collier Trophy winner, speaking at Propulsion Meeting luncheon. Head table at luncheon included (*left to right*) John H. Collins, Jr., N.A.C.A., Program Chairman; A. G. Cattaneo, Shell Development Company, Chairman of Afternoon Technical Session; Dr. E. R. Sharp, Director of N.A.C.A.'s Lewis Flight Propulsion Laboratory; John Stack; S. Paul Johnston, I.A.S. Director; W. A. M. Burden, I.A.S. President for 1949; Eugene W. Wasielewski, N.A.C.A., Chairman of the Cleveland-Akron Section; Ronald B. Smith, The M. W. Kellogg Company, Chairman of Morning Technical Session; Dr. S. D. Black, Case University, Secretary of Cleveland-Akron Section; and Benjamin Pinkel, N.A.C.A., Evening Technical Session Chairman. Dr. Sharp welcoming guests to Cleveland. (*Second row*) Misses Janette Sullivan and Irene Kives, N.A.C.A. Visitors inspecting company exhibits. Mrs. Mary L. Gosney and Miss Jean Millbach, N.A.C.A. (*Third row*) Exhibits of Jack & Heintz Precision Industries, Inc.; The Parker Appliance Company; Thompson Products, Inc.; and The B. F. Goodrich Company. (*Fourth row*) Exhibits of The Cleveland Pneumatic Tool Company; Pesco Products Division, Borg-Warner Corporation; and the American Steel & Wire Company. (*Bottom row*) S. Paul Johnston, I.A.S. Director, addressing luncheon group. Reception in the Embassy Room, Hotel Carter; followed by an informall dinner in the Baroom.

Details of Canada's First Jet Engine

Additional information has been released on the Chinook jet engine (AERONAUTICAL ENGINEERING REVIEW, November, 1947, p. 8), designed and built by A. V. Roe Canada Ltd.

Primarily a development engine built to supply the answers for larger models, the engine consists of a nine-stage axial-flow compressor, six combustion chambers, a single-stage turbine, and exhaust tail cone.

▸ **Compressor Rotor**—The compressor has a compression ratio of 4.5:1. The rotor is supported at the front end in a self-aligning roller bearing and at the aft end in a duplex-type ball bearing secured in a self-aligning mounting.

The drive for the accessories gear box is taken from the front shaft. The ninth stage disc of the compressor rotor is of steel, and the remainder of the discs are of aluminum alloy. Blades for the first and second rotor stages are made from stainless steel, while those for stages three to nine are of aluminum alloy. The blades are secured by either dovetail or fir tree serrations.

The magnesium-alloy stator casing is cast in halves and has one stage of precision-cast aluminum-alloy guide vanes followed by nine stages of stator blades made from aluminum alloy, secured to stator rings of the same material.

Each combustion chamber contains a perforated flame tube of Nimonic 75. The chamber itself consists of a cast aluminum front portion, while the rear portion is of fabricated mild steel. The six chambers are interconnected.

▸ **Turbine**—The turbine consists of a Jessop G.18B steel disc with an integrally forged stub shaft, fitted with Nimonic 80 turbine blades, which are secured by fir tree serrations at the roots. The stub shaft is mounted in a roller bearing and connected to the rear end of the compressor shaft through a flexible coupling, which compensates for angular misalignment. The turbine casing is fabricated from stainless steel; the nozzle guide vanes are of Vitallium.

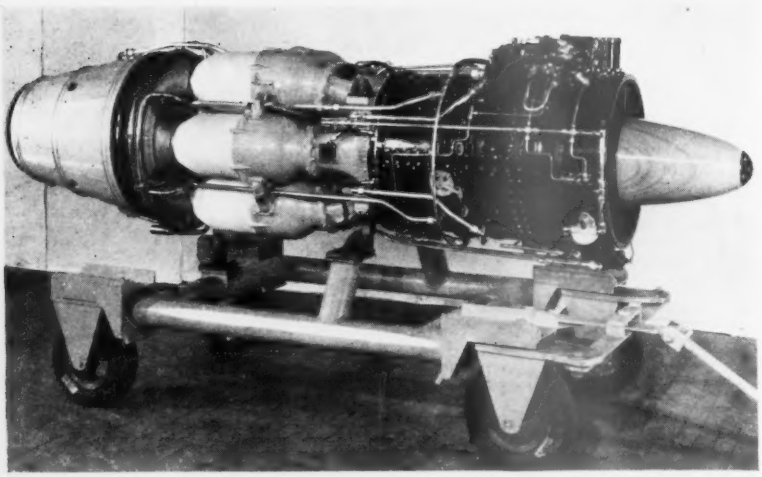
The exhaust tail cone and tailpipe are of stainless steel; the tailpipe is insulated by glass wool blankets encased in shields of silver foil under an aluminum outer covering.

A Lucas duplex fuel injection nozzle in each combustion chamber is supplied with fuel by two Lucas multiplunger, variable stroke, positive displacement pumps, which are connected in parallel to duplicated manifold pipe lines. Overspeed governors are integral with the pumps, and an interconnected servo system is incorporated. Maximum delivery pressure is 1,100 lbs. per sq.ft.

Other components of fuel system comprise a Lucas flow-control unit with an integral throttle valve, a shut-off cock low-pressure filter, a pressure regulating valve, a combined solenoid and torch ignitor reducing valve, and two torch ignitors.

▸ **Oil System**—The oil system is of the dry sump type, with vane and Gerotor type pumps supplying oil under pressure to the main bearings. One pressure and four scavenge units are incorporated. An integral oil tank, filter, and pressure regulator complete the system.

The Chinook is started by a Rotax electrical starter operating from a



Canadian Vanguard: *Avro Chinook is Canada's first jet engine, which was designed and built for the R.C.A.F. Larger, more powerful engines are being completed by A. V. Roe Canada as a result of the Chinook development.*

24-volt d.c. supply; two Rotax ignition coils are installed.

Diameter of the engine is 32 in.; length, 125.1 in.; frontal area, 5.6 sq.ft.; weight, 1,250 lbs. Fuel consumption (cr.) is 1.00 lb./lb.T./hr.; oil consumption (cr.) is 2.0 lb./hr. Performance: Take-off, static, 2,600 lbs.T. at 10,100 r.p.m./S.L.; climbing, static, 2,100 lbs.T. at 9,800 r.p.m./S.L., and cruising, static, 1,900 lbs.T. at 9,500 r.p.m./S.L.

Air Force Receives Republic Jet-Rocket Fighter

The experimental XF-91, a turbojet-powered fighter designed and built by Republic Aviation Corporation, which completed its taxi tests at the Farmingdale plant late in February and is now being tested at Muroc Air Force Base, has, in addition, four rocket units in the tail for accelerated take-off and climb and for operation at extreme altitudes above 35,000 ft. All performance figures are secret.

▶ **Inverse Taper**—The sweptback wings have inverse taper, and, because of their extreme thinness, the main landing-gear wheels are arranged in tandem pairs on each side. Retraction is outward, almost to the wing tips, while the nose wheel retracts forward into its wheel well.

The vertical and horizontal tail surfaces also are sharply swept back and are set relatively higher because of rocket units in the tail.

Wingspan of the aircraft is approximately 30 ft. and overall length is more than 45 ft.

Designed as an interceptor fighter to be used as a local defense weapon capable of combating enemy bombers and such missiles that come within its range and capabilities, the XF-91 is equipped with a pilot ejection seat, cabin pressurization, and refrigeration for the pilot at high speeds.

Instrument Firm Joins I.A.S.

Doelcam Corporation, with general offices and engineering laboratory at 56 Elmwood St., Newton, Mass., has joined the ranks of Institute Corporate Members, it was announced earlier this year.

With production facilities in its Manufacturing Department, 24 Brook St., Newton, Doelcam is engaged principally in the design, development, and production of precision instruments for the guidance, control, stabilization, and flight testing of inhabited and pilotless aircraft.

The number of employees is approximately 160, and total floor space is about 35,000 sq.ft., about half of each of which is devoted to engineering activity.

▶ **Variety of Instruments**—The precision instruments developed by the company include a variety of automatic pilots; servomechanisms; rate measuring gyroscopes; attitude and directional gyroscopes; integrating rate gyroscopes, accelerometers; yaw and angle-of-attack indicators; and electronic regulators for the control of voltage, frequency, and current.

The engineering staff at Doelcam, as well as the facilities of its fully equipped model shop and electronic, mechanical, and instrument test laboratories, is said to be ideally suited to the study of unique and challenging instrumentation design problems.

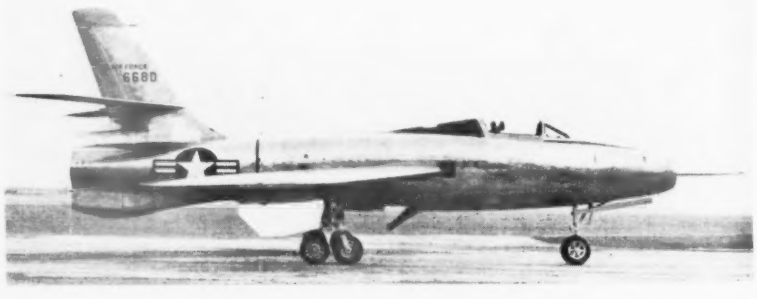
The production facilities are devoted to the manufacture, calibration, and testing of various flight-control and test instruments developed by the Engineering Department and to the contract production of precision mechanical and electromechanical assemblies, including elements of television, radar, and general electronic equipment.

Steve Zand Awarded Medal for Merit

In a ceremony held at the Pentagon, Dr. Stephen J. Zand, an I.A.S. Fellow and Vice-President-Engineering, Lord Manufacturing Company, Erie, Pa., received the Medal for Merit for his outstanding services in the war.

The citation, signed by President Truman, lauded him for exceptionally meritorious conduct in the performance of outstanding services to the United States from May, 1944, to September, 1945.

As Air Technical Representative, Hq. U.S. Strategic Air Forces, in Europe, and as a member of the United States Strategic Bombing Survey, he contributed immeasurably to Air Technical Intelligence during the past war, the citation read. "His initiative, remarkable linguistic abilities, broad knowledge of aeronautics and especially controls, his complete



For Local Defense: *Republic Aviation's new jet-rocket fighter, XF-91, bears a certain resemblance to the F-84 in the fuselage, but thereafter the similarity fades. The wings not only are sharply swept back, they have inverse taper; main landing gear wheels are set in tandem pairs on each side, and four rocket units are to be included in the tail, in addition to the turbojet power plant. Like the F-84, the jet intake is in the nose, from which protrudes the pitot tube.*

and thorough report writing technique—coupled with an uncanny intelligence awareness—made his services indispensable to our war effort," the citation continued, and concluded, "Dr. Zand's outstanding performance of duty during this period reflects great credit upon him and upon this country."

A party was given in his honor by Tom Lord, President of Lord Manufacturing, after the ceremony.

Meckley Winner of G-E Honor

William O. Meckley, I.A.S. Member and Application Engineer, Aircraft Gas Turbine Division, General Electric Company, and Lee J. Fischer, another member of the Division, were awarded the company's highest honor, the Charles A. Coffin Award. The honor was in recognition of outstanding work in designing and developing a high-performance reciprocating engine and turbosupercharger cycle.

▸ **Used with Wasp Major**—The cycle they developed is used in the variable discharge turbine power-plant installation for aircraft.

Known as the Wasp Major-VDT, the new piston-jet propulsion combination designed by Meckley and Fischer, in cooperation with Pratt & Whitney Aircraft, consists of a 28-cylinder Pratt & Whitney Wasp Major engine and a two-stage G-E variable discharge turbosupercharger. Capable of delivering more than 4,000 hp per propeller, as well as several hundred pounds of jet thrust, the power plant is said to be the most powerful of its type in the world today. It also is the most economical of all aircraft power plants built to date, General Electric says.

Installed in one of the Air Force's biggest bombers, it has been described as a power unit that can make the much sought after 10,000-mile bomber a practical success.

Both Fischer and Meckley, who have been with General Electric 12 and 8 years, respectively, have been connected with turbosuperchargers and other gas-turbine developments for most of their time with the company.

LITTER PATIENT LIFT

Claimed to be the first rotary-wing aircraft designed with a hatch large enough to permit the hoisting of litter patients directly into the interior of the cabin while in flight, the XHJP-1 can stow as many as three litters, in addition to the medical attendant in the cabin. The Piasecki helicopter also performed what is believed to be the first loop ever to be completed by a craft of its type during test flights at the Piasecki Helicopter plant at Morton, Pa. No structural failures were discovered as a result. Navy plans to use the XHJP-1 for plane guard, personnel transport, cargo delivery, aerial observation, etc., in shipboard operations.

I.A.S. Newslines

▸ Asks A-Bomb Report Release . . . **Dr. Karl T. Compton,** Chairman, Research & Development Board, an I.A.S. Fellow, agreed to carry demand for release of a Joint Chiefs of Staff evaluation report on the 1946 Bikini atomic bomb tests to President Truman if necessary. Group of scientists, including Dr. Harold C. Urey, who are asking for publication of the report, say services are minimizing bomb's power.

▸ Return Engagement . . . After 6 months of temporary duty as Physical Test Engineer, **Felix Kallis,** Associate Fellow, is back at jet engine testing, in charge of recently completed jet engine test cell at Ryan Aeronautical Company, San Diego.

▸ Far-Seeing "Eye" . . . A far-seeing eye that observes and records flight movements of experimental rockets soaring "something like 100 miles" into the sky was described by **Dr. W. B. Klemperer,** an I.A.S. Fellow and Douglas Aircraft Company missiles research engineer, before Institute of Navigation meeting at Allen Center, U.S. Naval Base, Terminal Island, Los Angeles, last February 26. Device is known as a heliographic altitude recorder.

▸ Shipbuilder . . . **Vice Adm. Emory S. Land,** U.S.N. (ret.), an I.A.S. Fellow, has been elected a Director of Newport News Shipbuilding & Dry Dock Company.

▸ Chart Maker . . . Associate Fellow **Thoburn C. Lyon,** Consultant on cartography and air navigation, has been President of Aeronautical Services, Inc., since last September.

▸ From Planes to Rockets . . . After 20 years with Curtiss-Wright, **Howard R. Moles** resigned as Project Engineer at the Columbus Plant to become Chief Engineer with Reaction Motors, Inc., Dover, N.J. Mr. Moles, an Associate Fellow, finds the work interesting and fascinating.

▸ Broadens Research . . . Research facilities in universities and other civilian institutions are to be sponsored by the Air Force as a part of a program to broaden and bolster its own scientific effort, according to **Gen. Hoyt S. Vandenberg,** Air Force Chief of Staff and I.A.S. Honorary Member. The policy also would liberalize methods of letting contracts and hiring consultants for research on new materiel and weapons.

▸ In Pasadena . . . **Theodore von Kármán,** Honorary Fellow, is located at 1501 South Marengo Ave., Pasadena, Calif., as of March 1.

▸ NBS Department Head . . . Associate Fellow **C. L. Zakhartchenko,** has been appointed an Engineering Department Head and Consultant on Aerodynamics and Propulsion of the National Bureau of Standards, Washington, D C.

Silicone News

DC SILICONES

DC Silicone Fluid Stabilizes Versatile Force Measuring Device

Thrust, torque and other kinds of force are measured by air in a device so sensitive and versatile that the same unit can measure the thrust of a 2000 h.p. engine while responding to the weight of a coin. It is used in the cradle dynamometer measurement of aircraft and automobile engines, the testing of piston rings and axles and automatic batch weighing. And it operates without any movement of the measured system.

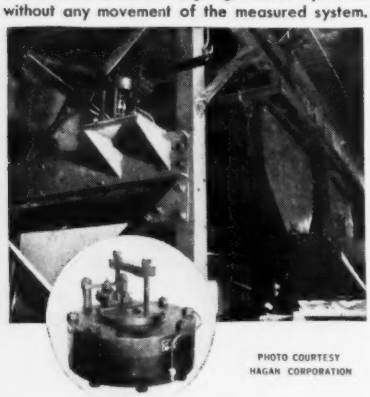


PHOTO COURTESY HAGAN CORPORATION

Accuracy of air operated, null displacement "ThrusTorq" is stabilized by DC 200 Fluid in viscous damper.

The "ThrusTorq" made by Hagan Corporation of Pittsburgh is essentially an air chamber, one side of which is a flexible diaphragm. A poppet valve admits compressed air until pressure in the air chamber exactly balances the force exerted on the diaphragm by the torque arm. When the force is reduced, air is exhausted to maintain equilibrium. Air pressure required to balance the force is registered by a manometer, or gauge calibrated in foot-pounds.

But the stability of a system for balancing inertial forces depends upon adequate damping. That is done most effectively by DC 200 Silicone Fluids in a viscous damper consisting of two diaphragm chambers connected by a small orifice in the partition plate.

Critical damping and more compact hydraulic systems both depend upon the remarkably low rate of viscosity change in DC 200 Fluids over a wide temperature range. For more information about these silicone fluids including data on resistance to oxidation and to mechanical shearing, lubricity, water repellency and dielectric properties, phone our nearest branch office or write for booklet C13 S2.

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Corporate Member News

• Bell Adding to Payroll . . . About 800 workers are to be added to **Bell Aircraft Corporation's** payroll by July 1 in connection with its $7,900,000 subcontract to build parts for the Boeing B-47. New workers will bring total to 2,800, a 50 per cent increase over last December's total.

• Bendix Earnings Up . . . Sales and earnings of **Bendix Aviation Corporation** were higher in the first quarter of the company's current fiscal year than in same 1947 period. However, "current trends in business activity will unquestionably challenge continued earning power," said Malcolm P. Ferguson, Bendix President. Consolidated gross sales, royalties, and other operating income for 3 months ended December 31, 1948, first quarter of fiscal 1949, amounted to $49,586,998 compared to $38,991,753 for similar period previous year. Consolidated net income was $3,102,625 or $1.47 a share for the quarter, compared to $2,224,306 for corresponding quarter previous year.

• Spark Plug Cleaner . . . **The BG Corporation** has announced the addition of a spark-plug abrasive blast cleaner to its line of spark-plug servicing tools and testing equipment. Cleaner removes carbon and lead deposits from nose and shell of the plug in one simple operation, company says.

• Shades of 1929 . . . The Boeing B-50 nonstop flight round the world, covering some 23,400 miles in 94 hours, in which four refueling contacts were made with converted B-29 tankers, recalls the feat of (then) Major Carl Spaatz and (then) Capt. Ira C. Eaker, who, in 1929, flew 11,000 miles nonstop in the Fokker "Question Mark" in 151 hours, making 43 refueling contacts. British later developed the system that was in vogue in this country in late twenties . . . A $1.00 dividend was paid March 29 by **Boeing Airplane Company** to stockholders of record March 15.

• New Prop Control Unit . . . A new control unit for reversing propellers has been developed by **Consolidated Vultee Aircraft Corporation.** Invented by L. J. Bordelon, Chief Flight Engineer, the simplified unit performs all the operations accomplished by the multiple control relay installation now in use, Convair says, adding that the unit eliminates all reversing control relays . . . Heaviest pay load in aviation history was lifted last month by the Convair XC-99 at Ft. Worth plant, where it was brought February 11 for final phases of flight testing, when the big double-decked plane took off with a 100,000-lb. load.

• Reinstates CW-32 Project . . . **Curtiss-Wright Corporation** has reinstated the CW-32 cargo plane project and is re-evaluating it for ultimate production, according to William C. Jordan, Curtiss-Wright President.

• Seeks Coast-to-Coast Route . . . **Eastern Air Lines** has applied to the C.A.B. for an exemption order granting authority to it to provide immediate southern transcontinental route service for important cities of the Gulf Coast area, South, and Southwest. Granting of Eastern's application would allow the air line to connect Pacific with southwestern areas for the first time.

• Discontinues Personal Planes . . . The Personal Planes operation of **Fairchild Engine and Airplane Corporation** at Strother Field, Kan., has been discontinued following Fairchild's study of developments and potential in the light-plane field for many months. Sale of spare parts for F-24's and primary trainers, including the PT-19, will continue to be handled at Strother Field.

• Research at Lockland . . . In the 700,000-sq.ft. brick and concrete former plant of Wright Aeronautical at Lockland, Ohio, **General Electric Company** is conducting basic research into jet power plant that will operate efficiently at 70,000-ft. altitude and at —70°F. . . . An instrument that uses a stream of electrons to study a layer of metal less than a quarter-millionth of an inch thick is aiding N.A.C.A. engineers in their search for better metals and lubricants for jet engines. Developed by G-E, the "electron diffraction instrument" is used in determining the effects of various lubricants and in friction studies of polished metal engine parts. Another N.A.C.A. group is using the instrument in attempts to improve high-temperature metals. With it they can detect in a few seconds natural films that emanate from the steel itself and chemical changes produced on the surfaces by lubricants. These chemical changes, they say, are not visible under the microscope. By subjecting metal parts to temperatures and speeds that simulate actual flight conditions, then examining the parts with the instrument, researchers have been able to identify specific film materials normally deposited on the bearings when the engine operates. Used to study parts that have been worn by tests, the device has helped engineers to discover and minimize causes of friction.

• Oil Tank Stops 2,000° Flame . . . A new-type oil tank capable of withstanding fire and temperature of 2,000°F. has been developed by **The B. F. Goodrich Company** for the Navy. The flame-resisting container is also bullet-sealing for naval aviation uses. An outer coating, in which American-made rubber is combined with other materials, gives unusual resistance to heat and direct exposure to flame, thereby greatly increasing the safety factor of oil cells, particularly for installation in combat aircraft.

• Lear Buys Building . . . The seven-story brick building that has been occupied by **Lear, Inc.,** in Grand Rapids, Mich., on a rental basis, has been bought by the company. Floor area of the building is 171,000 sq.ft., including basement.

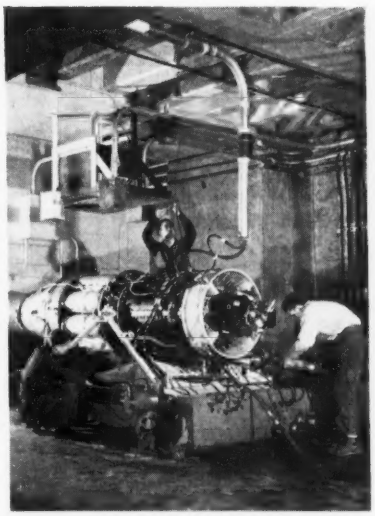
• Honeywell Acquires Valve Firm . . . **Minneapolis-Honeywell Regulator Company** has entered into an agreement for acquisition of the assets of the H. Belfield Company, control valve maker, to be known as the Belfield Valve Division of Minneapolis-Honeywell. Occupying a five-story building in Philadelphia, the Belfield company manufactures certain types of automatic valves not previously made by Honeywell.

• B-45 Jato Boost . . . **North American Aviation's** B-45 jet bomber now packs two Jato units, adding 8,000 lbs. thrust to the 20,000 supplied by the four J-47 engines and giving the plane greater all-round performance. North American has orders from Air Force for 139 of the jet light bombers, which went into production late in 1947.

• More XF-89 Specs . . . Assigned the official name of "Scorpion," new **Northrop Aircraft, Inc.,** XF-89 all-weather fighter (AERONAUTICAL ENGINEERING REVIEW, November, 1948, p. 11) is said to be in the 600-m.p.h. class. Plane is designed to operate at altitudes above 40,000 ft. and has been undergoing tests at Muroc since its initial flight August 16, 1948. Powered by two Allison J-35 turbojets, each rated at 4,000 lbs. thrust, Scorpion has design gross weight of more than 30,000 lbs. Wing span is approximately 50 ft., about same length, and is approximately 15 ft. high. Smaller than Northrop's Black Widow, it is considerably heavier. Extra thick wing skins are used to provide safer margin at high speeds. Ejection seats are provided for pilot and radar observer . . . Northrop is studying possibility of using atomic power to propel the Flying Wing.

• Lowest Coach Fare . . . Lowest coast-to-coast fare ever proposed by any air line—$97 from New York to Seattle—was offered by **Northwest Airlines,** beginning March 24 last.

• New Avro Jet Engine . . . First test run has been held for R.C.A.F.'s new jet engine, the Orenda, developed at the Malton plant of **A. V. Roe Canada Ltd.** Said to be the largest engine known to have reached a comparable stage of development in North America, the Orenda is the axial-flow type and is being groomed for possible use in the new long-range jet fighter also being developed by Avro.



LOCKLAND G-E TEST CELL

Readying the powerful J-47 gas turbine for its initial test in General Electric Company's Lockland, Ohio, plant, technicians are working in the first test cell completed since the company occupied the former Curtiss-Wright engine plant some 9 months earlier. More than 2,000 J-47 jet engines have been ordered by the Air Force.

• New Test for Oils . . . **Texas Company's** Beacon Laboratories have devised a new test for evaluating aircraft engine oils. Using a four-cylinder Continental aircraft engine, Texaco engineers have installed a temperature control system permitting simultaneous check of oil performance under different temperatures. Each cylinder is operated at a different temperature, with four thermocouples attached to each. Temperatures are averaged and fed into an automatic indicator. Motor-controlled dampers are used to maintain cylinders at desired temperature levels. Since engine cleanliness is closely tied to temperature problems, this test permits engineers to determine oil performance under wide temperature range on a single run. It also permits tests for bearing performance. Engine is attached to a dynamometer absorbing full-load horsepower output that normally would be transmitted to aircraft prop.

• 5,000 Subcontractors and Suppliers . . . To make possible last year's production of engines, propellers, and aircraft by the **United Aircraft Corporation,** 5,000 subcontractors and suppliers in 36 states were required. Pratt & Whitney alone required parts, raw materials, supplies, and services from more than 4,000 firms.

• Declares Dividend . . . **Wright Aeronautical Corporation** directors declared a dividend of $1.25 per share for first quarter of 1949 on all capital stock issued and outstanding, payable March 28 last to stockholders of record on March 17.

Necrology

Andrew V. D. Willgoos

Andrew V. D. Willgoos, 60, Chief Engineer of Pratt & Whitney Aircraft, East Hartford, Conn., since the engine company's founding 24 years ago, died of a heart attack March 1 at his home in West Hartford. His death came within a few weeks after that of Dr. George J. Mead, engineering co-founder of Pratt & Whitney, with whom he worked closely in evolving the design of what became the first of the famous line of Wasp engines.

▶ **Leader in Design**—Mr. Willgoos, a Fellow of the Institute, was one of the foremost contributors to aircraft-engine design for the last 34 years and was responsible for the detail design of all engine models undertaken by Pratt & Whitney since the company was formed in 1925. He had been closely associated with all the series of Pratt & Whitney Aircraft developments which reached their present peak in the design of the 28-cylinder engine, which powers the B-36.

One of the half-dozen men chosen by Frederick B. Rentschler, now Chairman of the Board of United Aircraft Corporation, to form Pratt & Whitney Aircraft, Mr. Willgoos was assigned the design of the power section—the most important part—of the first Wasp engine on which the hopes of the company were pinned.

▶ **English Parentage**—Mr. Willgoos was born of English parents on a farm at New Brunswick, N.J., on October 31, 1888. His father was an expert machinist, and the farm boy was soon making mechanical drawings and using his father's tools to execute the designs. At the age of 13 he built his first engine—a steam-driven device using a 40-qt. milkcan as a boiler.

From high school he went to his first job, at the age of 17, as a messenger in the blueprint department of the Western Electric Company in New York City. At night he studied courses in mechanical engineering and soon won a transfer to the company's drafting room as a tracer and draftsman.

In 1907 he began work as a draftsman with Viele, Blackwell & Buck, consulting engineers in New York, and assisted in the design and layout of hydroelectric power plants. Two years later he joined the Standard Plunger Elevator Company in New York.

In 1911 he applied for a job as draftsman with the old Simplex Automobile Company at New Brunswick and was selected from a large number of applicants by the company. When the firm, as the Crane Simplex Automobile Company, began building the Hispano-Suiza aircraft engines for the Allies in 1915, Mr. Willgoos was chief draftsman in charge of the work on the various models of the French engine.

He continued as chief draftsman when Wright-Martin Aircraft Corporation took over the plant in 1917.

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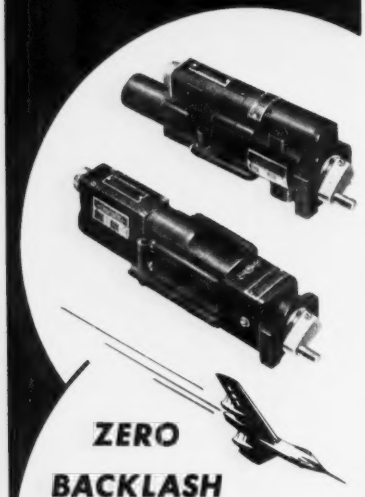

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. . . resulting from the special preloaded balanced torque gear train eliminates lost motion in the system which is essential on all high speed aircraft. NO OTHER ROTARY ACTUATOR PROVIDES THIS FEATURE.

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When the Wright Aeronautical Corporation succeeded Wright-Martin and moved to Paterson, N.J., Mr. Willgoos became Assistant Engineer in charge of design under Mr. Mead, who was Chief Engineer.

He resigned in July, 1925, to join Mr. Rentschler in the formation of Pratt & Whitney and in April, 1929, was elected a Director.

A quiet-spoken man, Mr. Willgoos always preferred that credit for the successive engines to be spread as widely as possible among all those on his staff who contributed to their development.

T. G. McClelland

Thomas G. McClelland, former U.S. Navy flier and Chance Vought Aircraft test pilot, was killed in an auto accident last December 21 at Albuquerque, N.M., where he returned with his family a year ago March to his home.

▶ **Won DFC**—During the war he served 4½ years in the Navy Air service as a Lieutenant in the Pacific Theater with a shipboard fighter squadron, where he was awarded several decorations including the Distinguished Flying Cross.

He then was assigned to duty with the Flight Test Division, Naval Air Test Center, Patuxent River, Md., as Flight Test Project Pilot. In that capacity he displayed unusual energy in acquainting himself with the engineering principles involved in flight-test work, becoming an expert test pilot. He was described by his fellow officers as an extremely able Naval Aviator and an intelligent officer with a well-developed "engineering sense."

Lieutenant McClelland attended Knox College, Galesburg, Ill., in 1938–1939, and the University of New Mexico, Albuquerque, in 1939–1941, where he took a liberal arts course. He was born in Lethbridge, Alberta, Canada, July 12, 1920.

▶ **Joins Vultee Aircraft**—Following his graduation from the University, he accepted a position as an aircraft engine mechanic with Vultee Aircraft, Inc., at Downey, Calif., where he worked on the BT-13 and P-66.

In March, 1942, he joined the Navy as an Aviation Cadet and took flight training; he won his wings as Naval Aviator and was assigned as a carrier-based combat flyer in January, 1943. He flew 33 combat missions.

Toward the end of the war in the Pacific, in June, 1945, he was given the assignment at Patuxent River.

After his separation from the Navy he was employed at Chance Vought Aircraft in Stratford, Conn., as a test pilot on the XF6U-1. He left Chance Vought in February, 1948, to return to his home in Albuquerque where he had been engaged in business since May, 1948.

He is survived by his wife, Mildred M. McClelland, and a 1-year old son, Thomas Bruce.

Rifat Avigdor

Rifat Avigdor died early in March at the age of 53 in Toronto, where he was employed by Canadian Aircraft Instruments & Accessories Ltd. as a Technical Director on aircraft instruments.

The inventor of many aircraft accessories and instruments on which he had taken out patents, Mr. Avigdor was born in Constantinople, Turkey, August 9, 1895, where he was educated at the Deutsche Oberreal Schule from 1901–1912. Later, he went to Budapest to the Technishe Hochschule, 1912–1916, where he studied electrical and mechanical engineering. In 1916 he went to Berlin where he attended the Algemeine Electrisitaets Gesellschaft until 1919.

From 1919 to 1943 Mr. Avigdor worked on the design and production of aircraft accessories, such as fuel pressure pumps, fuel filters, aircraft tubing, instruments, as owner and part owner of plants in Germany, Holland, England, and Canada. These included Niederlandische Pompen Mij., The Hague, Holland; Deutsche Benzin Uhren, Berlin; Self-Priming Pump & Engineering Co. Ltd., Slough, Bucks., England; Korect Depth Gauge Instruments Ltd., Croydon, Surrey, England; and the Canadian Aircraft Instruments & Accessories Ltd., Leaside, Ontario, Canada, where he arrived in 1941.

He was responsible for the development of the electrically driven emersed fuel pump, which was successfully used by the Germans and the British. He left Germany because of political reasons.

Robert L. Slifer

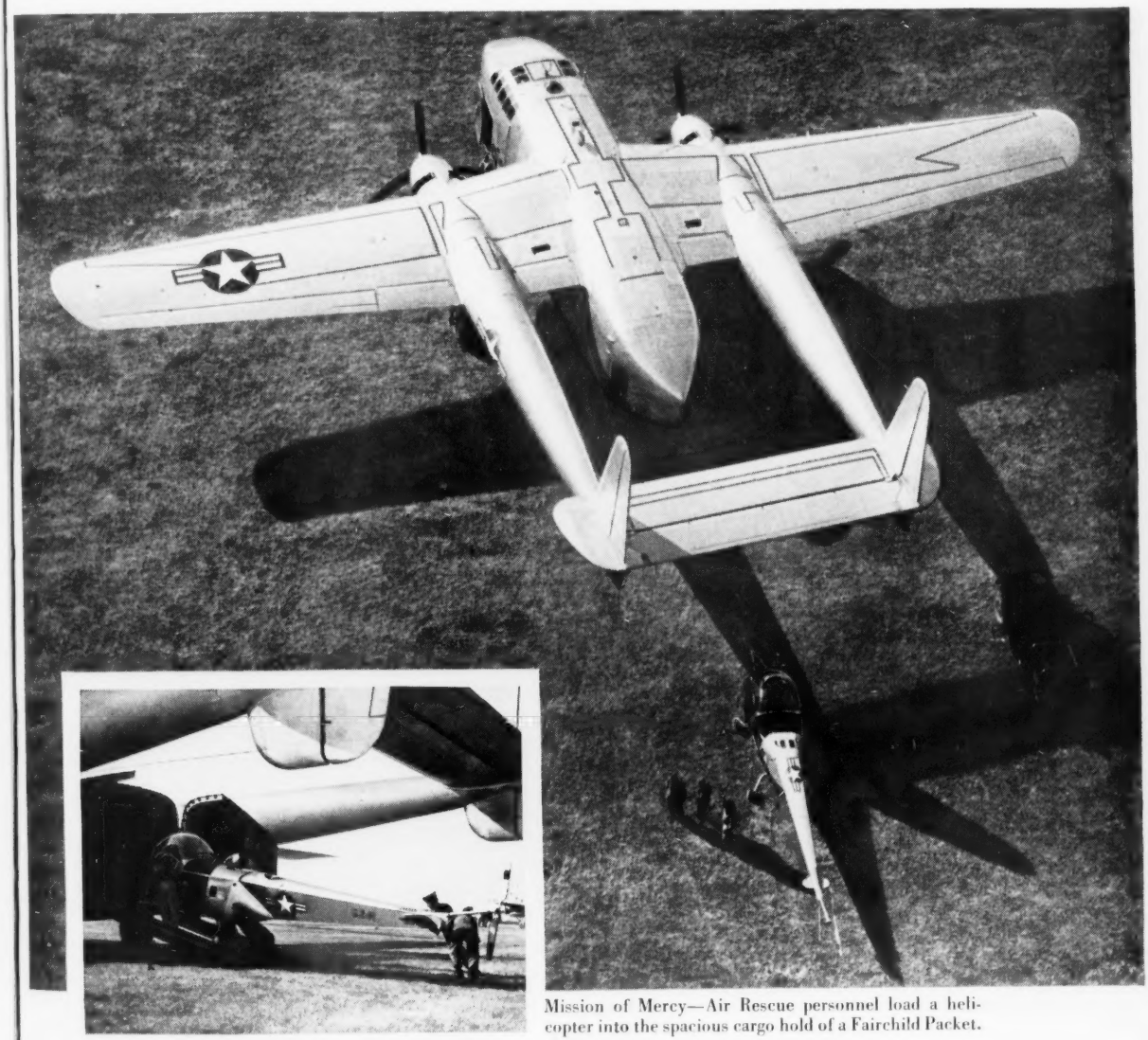
Robert Lewis Slifer, Senior Meteorologist for Mid-Continent Airlines, Inc., died at Wadsworth General Hospital, Wadsworth, Kan., last December 18. He was only 30 years old.

He was graduated from the University of Minnesota in June, 1940, with a Bachelor of Aeronautical Engineering degree. He had a major in airplane design and minor in meteorology and was a Student Member of the Institute while attending the University.

He was named a Meteorologist at Mid-Continent Airlines in Kansas City, Mo., right after graduation, where he remained until he was commissioned a second lieutenant in the

AIR RESCUE

Over faraway jungles, deserts and mountains, helicopters of the USAF Air Rescue Service have flown in search of stranded airmen and passengers. The helicopters got there because they have been given a "mother" ship—the Fairchild Packet—that transports them over distances far beyond their range. Thus, our Air Force has added a new ability to the versatile Fairchild Packet—increasing the importance of its part in the development of modern airborne military tactics.



Mission of Mercy—Air Rescue personnel load a helicopter into the spacious cargo hold of a Fairchild Packet.

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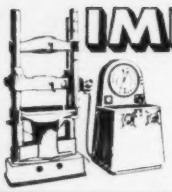
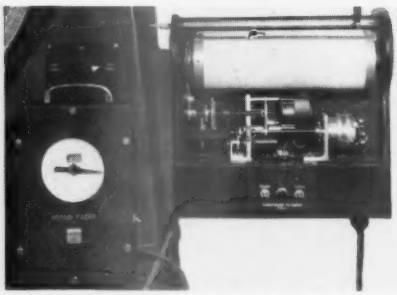


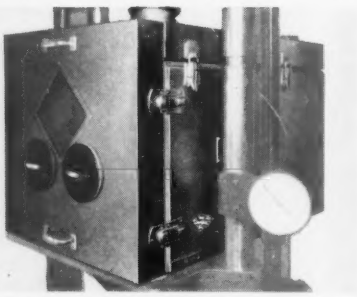
IMPORTANT -to testing machine owners

These accessories will broaden the usefulness—increase the value—of your present equipment

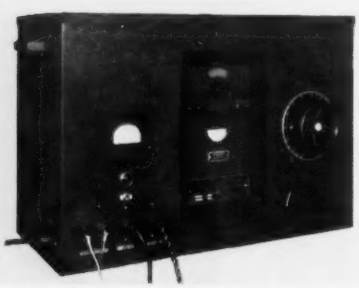
✓ Tate-Emery Air Cell extends precision range of testing machine downward to as little as 2 pounds, full scale. Portable or built-in indicator. Bulletin No. 264.



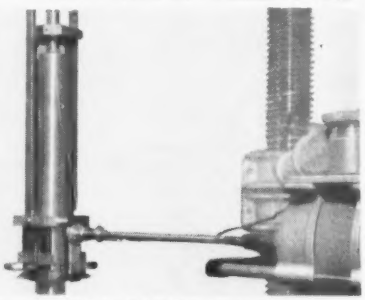
✓ Baldwin Strain Pacer permits maintenance of a constant rate of displacement between specimen gage points, rather than a constant rate of crosshead separation. Bulletin No. 289.



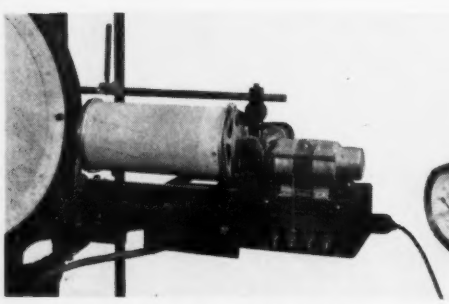
✓ Baldwin Controlled-Temperature Cabinet machine permits tension, compression and flexure tests at temperatures from —70° F to +200° F, maintained within ±1°. Bulletin No. 284.



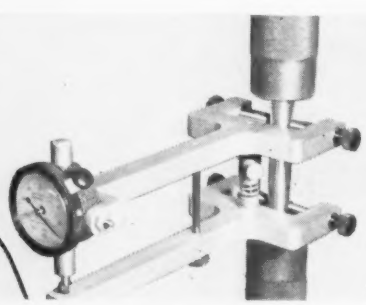
✓ Furnace and Control Panel for high-temperature testing, provide temperatures up to 1800°F (up to 2000°F on special order). Temperature uniformity up to ±3° is readily obtainable, and maintenance within 1° is not uncommon. Bulletin No. 261A.



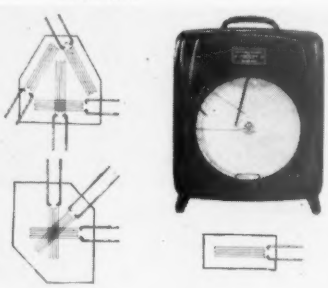
✓ Baldwin PSH-8 extensometer (microformer model PSH-8M), for use with standard threaded-end specimens at temperatures up to 1600° F. Bulletin No. 262.



✓ Baldwin Stress-Strain Recorders. Models available for virtually all common makes of testing machines. Bulletin No. 262.



✓ H. F. Moore indicating extensometer accommodates round or flat specimens up to 8 inches in length. Bulletin No. 263.



✓ Baldwin *SR-4 Strain Gages and other associated equipment have become an invaluable tool in stress analysis.

*Trade-Mark Registered U. S. Pat. Off.

These illustrations show only a few of the many Baldwin accessories that will implement existing machines for broader fields of use, and make them an even more valuable tool in scientific progress and industrial development. Some of these accessories can be used on any make of machine . . . others are limited to certain types. You will find complete information on each individual device in its special bulletins; the numbers are listed.

A new bulletin on grips and accessories—No. 261-A—is just off the press. It lists a number of the items illustrated, as well as others, and will be a helpful addition to your testing equipment file. We will be glad to send a copy on request.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U.S.A. Offices: Boston, New York, Philadelphia, Houston, St. Louis, Chicago, Cleveland, Pittsburgh, San Francisco, Seattle, Washington. In Canada: Peacock Brothers, Ltd., Montreal, Quebec.

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Army Air Forces as a Weather Forecaster. He was in the service until June, 1946, in charge of setting up some of the weather stations in Alaska, and analyzing weather maps and charts for use in advising Air Transport Command pilots and Russian ferry pilots on weather conditions. As Station Weather Officer, he commanded from 10 to 25 men.

Upon separation from the Air Forces, he returned to Mid-Continent as Senior Meteorologist. He was a Member of the American Meteorological Society, as well as of the Institute.

Jack E. Frick

Death of Jack E. Frick at the age of 33 made an extremely untimely end of his aeronautical career. He died in North Hollywood, Calif., on January 2, a little more than a month before his next birthday, February 22.

Born in New York City, he was graduated from New York University with a Bachelor of Aeronautical Engineering degree, and in June, 1938, he was employed at Wright Aeronautical Corporation as Engine Tester for a year. He then went to the West Coast to Vega Airplane Company in Burbank as an Engineer working on design power-plant installations. Later he worked as Layout Draftsman on the Ventura power-plant installation, and from August, 1940, to April, 1941, was in charge of test stand design, conducting Ventura power-plant ground tests as well as ground fuel system tests.

In 1941 he was promoted to Flight Test Engineer on Lockheed Venturas, Hudsons, Lodestars, and the Constellation. This job consisted of planning, conducting, and analyzing tests. His associates described him as extremely capable and well liked.

Meet Your Section Chairmen

Robert B. Dale

Detroit Section

Robert Baker Dale, whose experience in aeronautics embraces maintenance, overhaul, and alteration of civilian aircraft and design and construction of light planes, as well as instructor in the above fields, got an early start in his chosen career by building models when a boy in Detroit, where he was born July 18, 1917.

▸ **Building Amphibian**—An Instructor on the Detroit Board of Education Aero Mechanics Vocational High School staff, Dale recently saw the first flight of an experimental two-place amphibian of which he is the co-designer and builder, under the firm name of Ensign Engineering Company. The plane, result of a project begun November, 1938, in part and full-time work, is now at flight test stage.

Educated at Wayne University, where he was graduated with a B.S. in Aeronautical Engineering in June, 1941, he has held a position with the Detroit Board of Education as an Instructor and Supervisor of Instruction since September, 1940, interrupted by work during the war years as Superintendent of the Factory Liaison Group for Briggs Manufacturing Company. There he coordinated all phases of production of the aircraft components that were built.

He is now back with the Board of Education in his old job of Instructor.

He holds an Aircraft Mechanics Certificate, is a Michigan State Registered Professional Aeronautical Engineer, and is a C.A.A. designated Aircraft Mechanics Examiner. He is a member of the Detroit Schoolmen's Club and of the Engineering Society of Detroit.

Married, Dale has a 6-year-old son with whom he enjoys his favorite means of relaxation—assisting and guiding him in his play. Other activities include fishing, lake and stream, and 8-mm. movies, which he likes to take and show.

Herman C. Wieben, Jr.

Hagerstown Section

A slump in ship building in the late twenties launched Herman C. Wieben into aeronautics as a career.

In 1928 he received a scholarship from Webb Institute of Naval Architecture, of which he is a graduate, to study aeronautical engineering at New York University, Guggenheim School of Aeronautics. Shipbuilding at that time was inactive, and there was little promise of improvement in the foreseeable future, whereas in aviation a stimulus had been provided by the transatlantic flights of Charles A. Lindbergh, Richard E. Byrd, Clarence Chamberlin, and others in the preceding year. In due course, Mr. Wieben received the A.E. degree from N.Y.U.

▸ **Ship Influence**—Nevertheless, the sea tang of naval architecture left a permanent imprint upon his development in the aeronautical field. He had, meanwhile, obtained a job as Draftsman with the Gates-Day Aircraft Company, Paterson, N.J., and in 1929 he went over to Keystone Air-

Regional Meeting, Washington, D.C., May 19, 1949

The Washington, Philadelphia, Hagerstown, and Baltimore sections of the Institute are cooperating in arrangements for a regional meeting to be held in Washington, D.C., on Thursday, May 19. The meeting will be held in the auditorium of the Department of the Interior, C Street between 18th and 19th, Northwest, and begins at 8:00 p.m.

The speaker for the evening will be Dr. Hugh L. Dryden, Director of Aeronautical Research, National Advisory Committee for Aeronautics, who will present his paper on "The Aeronautical Research Scene—Goals, Methods, and Accomplishments."

Special importance is attached to this occasion, since Dr. Dryden's paper is first being presented in London on April 28 as the Thirty-Seventh Wilbur Wright Memorial Lecture to the Royal Aeronautical Society. The objectives of this meeting are to broaden relationships between Institute members in this region and to promote closer cooperation among the sections.

craft, Bristol, Pa., as a Draftsman specializing in hull and float work.

Three years later Mr. Wieben was in Buffalo at the Curtiss-Wright plant as a Stress Analyst and Engineering Draftsman in charge of stainless-steel spot-welded floats. He remained with Curtiss-Wright until 1935 when The Glenn L. Martin Company offered him the kind of opportunity he was looking for—Design Engineer in charge of hulls, fuselages, and floats in practically all Martin airplanes. He held this position until 1941 and then was named Chief Project Engineer in charge of design on all Martin production contracts. Altogether, he was with Martin 12 years.

▶ **Joined Fairchild**—Today, Mr. Wieben is Head of Production, Projects Division, Fairchild Aircraft Division, Hagerstown, where he has worked for the past $1^1/_2$ years.

In his present work he directs activities of all production project design groups, checking groups, standards group, and drawing change group.

Married, with two daughters, Mr. Wieben enjoys music as a hobby. But his favorite means of relaxation is—you guessed it—sailing.

I.A.S. Sections

Boston Section

W. G. Cornell, *Secretary*

Approximately 100 members, guests, and student members attended the March 3 meeting, which was opened by ast year's Chai. man, Prof. Richard von Mises. William G. Cornell announced the results of the election of officers as follows:

Chairman, Prof. Otto C. Koppen; Vice-Chairman, William O. Meckley (see story in General News, page 9); Treasurer, Prof. Gustav Kuerti; and Secretary, Wi liam G. Cornell.

▶ **Research Challenge**—Professor von Mises then introduced Professor Koppen, who introduced the first speaker of the evening, Eugene E. Stoeckly, Division Engineer, Basic Development Division, General Electric Company, Lynn, Mass., who spoke on "The Research Challenge of Aircraft Propulsion to the Universities."

Mr. Stoeckly discussed the roles of reciprocating engines, jet engines, and rocket engines in aircraft propulsion. In his talk, numerous variants of the basic types were considered, among which were the following: compounded reciprocating engines, prop-jets, more complicated gas-turbine cycles, free piston engines, pressure wave compressors, ducted fans, augmentation of jet engines by mass addition, and afterburning.

▶ **Urgently Need Solutions**—A performance comparison study was illustrated by slides showing aircraft speed versus range with parameter aircraft load/fuel load at various altitudes. Engine types compared were the reciprocating, prop-jet, jet, and ram-jet. The speaker then discussed specific jet engine problems in urgent need of solution.

Among these problems were: design of small, light, high-performance, high-output engines; development of broader theories of three-dimensional sub- and supersonic flow; analysis of losses in turbomachines; development of high-speed, high-performance airfoil shapes for turbomachines; development of theory of combustion; development of theory of off-design performance of turbomachines; development of better high-temperature materials; development of theories of elasticity and vibration at elevated temperatures.

▶ **Recent Developments**—Professor Koppen then introduced the second speaker, Raymond E. Small, Division Engineer, Commercial Engineering Division, G-E. The talk was on "Recent Developments in Turbojet Applications to High-Speed Aircraft." Mr. Small discussed application problems in three broad categories:

- Refinement of production engines, particularly in view of quality control and engine life.
- Rerating production engines, particularly by component improvement and augmentation.
- New designs for same frame size.

General interesting problems were discussed in detail, among which were the use of various fuels in the same engine, winterization of engines, and deicing of engine inlets. Recent flights of Boeing XB-47, Northrop YB-49, North American F-86A, as well as the recent flight refueling tests, were discussed. Slides and motion pictures illustrated Mr. Small's talk.

Buffalo Section

Alexander Krivetsky, *Secretary*

The February 16 meeting featured a paper on "Stability and Control of Supersonic Aircraft," by A. F. Donovan, Head of the Aero-Mechanics Department, Cornell Aeronautical Laboratory, Inc. The Chairman, George D. Ray, presided with 40 members present.

▶ **Classical Assumptions**—Mr. Donovan presented a short history of the theory of stability, together with some of the classical assumptions, indicating a similarity in the basic theory of stability and control if the validity of the classical assumptions is accepted and if the appropriate aerodynamic derivatives are inserted in the equations of motion.

A principal difference between supersonic and subsonic flow, Donovan said, lies in the different nature of the induced flow effects. Because of the large tail to wing size characteristic of supersonic aircraft, the lift, side force, and rolling moment of the tail often cannot be neglected as it is done subsonically, and down-wash becomes an important factor.

Mr. Donovan analyzed a hypothetical supersonic airplane of conventional design to illustrate some of the stability effects over a wide range of Mach Numbers. Slides were used to illustrate some of the points.

A new Secretary, Alexander Krivetsky, was appointed to replace Harrison Dunlavy, who has left the area, at a business session preceding the presentation of the paper.

Cleveland-Akron Section

S. D. Black, *Secretary*

On February 23, with Chairman Eugene Wasielewski presiding, a paper entitled "Design for Gas Turbine Material" was given by Herman H. Hanink, Head of High Temperature Materials Group, Wright Aeronautical Corporation, who substituted for M. H. Young, originally scheduled to give the paper. Fifty persons were present.

Columbus Section

Harold E. Heberding
Acting Secretary

A paper on "Physiological Responses to Explosive Decompression" was given at the February 15 meeting by Dr. Fred Hitchcock, Director, Laboratory of Aviation Physiology and Medicine, Ohio State University.

During the meeting, it was announced that while the Section Secretary, Ferdinand L. Jesse, is working at Boeing—Seattle, H. E. Heberding would handle the secretarial duties.

Latest versions of the U. S. Navy's Lockheed P2V Search-Patrol Plane are cooled by Clifford Feather-Weight All-Aluminum Oil Coolers. The P2V's are the first search-patrol planes ever designed "from the ground up" for the Navy. One of this series, the "Truculent Turtle" holds the world's non-stop distance record of 11,236 statute miles for a flight from Perth, Australia to Columbus, Ohio in the fall of 1946. Production of the P2V's is under way at Lockheed Aircraft Corporation Factory at Burbank, California.
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Los Angeles Section

Edwin P. Hartman, *Secretary*

A report on the research, carried out by Lockheed in its altitude tank, in determining the effect on perishable farm produce of environmental conditions (pressure, temperature, and humidity) prevailing in the fuselage of a cargo plane was made at the February 24 meeting.

Chairman Joe Barfoot opened the Section's first 1949 dinner meeting and technical session and then turned the meeting over to the Program Chairman, Al Cleveland, who introduced the principal speakers—Dr. B. A. Rose, Head of Lockheed's Mechanical Research Group, and H. P. Huff, Chief Engineer of Slick Airways.

▶ **Sky's the Limit**—Although one would scarcely anticipate carrying strawberries, tomatoes, and other farm produce to an altitude of 50,000 ft. at a rate of 5,000 ft. per min., if such an occasion should arise, it is now known what would happen to the produce—nothing.

Dr. Rose's talk centered on a bit of original research sponsored and encouraged by organizations including Air Cargo Institute of California, U.S. Department of Agriculture, University of Southern California, and others.

Thirty-four different varieties of vegetables and fruits, available locally in November, 1948, were exposed to a wide variety of controlled conditions—pressure altitude to 50,000 ft., rate of climb to 5,000 ft. per min., relative humidity from 24 to 70 per cent, temperature from 35° to 83°F.—and later were compared with control lots of the same produce that had not been subjected to the principal test condition.

The principal results, Dr. Rose said, were that, while humidity and temperature control are as important in the cabin of a produce-carrying cargo plane as they are in any other place where such produce is stored, the effect of pressure and pressure variations occurring in high flying planes is for all practical purposes insignificant.

Future research on air transportation of perishables, the speaker declared, might well include investigations of the effect of altitude on poultry and sea food, the effect of vibration on farm produce, the application of thermal insulation for temperature control, and simple means of effecting humidity control.

▶ **Air-Freight Operations**—Mr. Huff presented a picture of the air-freight operations of Slick airways.

Unlike military airlifts, said Huff, the commercial air-freight carrier, to survive must operate at low cost. For the commercial operator, the fight to reduce cost per ton-mile is a bitter and relentless struggle. Toward this end Slick has (1) developed extremely efficient freight handling equipment and techniques; (2) eliminated autopilots and other "frills" from its planes; and (3) made use of 91-octane instead of the more costly (2 cents per gal.) 100-octane fuel whenever (about 58 per cent of the time) possible, he said. Crews are changed three times in a transcontinental flight, each crew putting in about 5 hours of flight time.

A factor affecting the scheduling and efficiency of air-freight operations, Huff continued, is the almost universal desire of shippers to send off their freight in the afternoon, and the equally universal demand of consignees to receive shipments in the morning.

▶ **Greatest Need**—The greatest need of air-freight operators, Huff said, is for an airplane designed specifically for freight carrying. Important specifications for the ideal air freighter would, he stated, include: (1) economy of operation, (2) reliability, and (3) speed. Economy that would lower direct costs to something around 4 or 5 cents per ton-mile is desired. Reliability, and all-weather design, are required that would permit a larger percentage of on-schedule take-offs and on-time arrivals than is achieved in air passenger operation. A passenger, he said, may be delayed without too serious consequences but not a load of strawberries. The speed of the ideal air freighter should permit a transcontinental passage in about 6 hours; thus a cargo could be loaded at Los Angeles in the evening and unloaded and delivered in New York in the morning.

Should the ideal air freighter be pressurized? The cargo-carrying space, according to Dr. Rose, need not be but if the airplane is to cross the country in 6 hours, it must fly high, and there will be need to pressurize the cockpit. However, with only the cockpit pressurized, Huff pointed out, the crews will be unable to make the sometimes necessary in-flight inspection of cargo.

▶ **Specialized Problems**—Among specialized problems confronting the air-freight carrier are:

- Development of efficient means of loading and unloading. At present from 1 to 1½ hours are required by Slick to load and unload a 10,000-lb. cargo in parcels averaging 40 lbs.
- Damage to exterior and interior of the plane during loading and unloading operations by trucks, tractors, and other freight-handling equipment. Such accidents are frequent; they affect schedules and represent a substantial drain on materials and labor.
- Development of cheap and simple means of humidity and temperature control. Prepackaging, in pliofilm bags, to provide some degree of humidity control has been tried to a limited extent. To avoid involvement with the Pure Food & Drug Act, as well as to provide pressure equalization within the bags, the bags are not completely sealed.

Philadelphia Section

J. Albert Ray, *Secretary*

An interesting paper on the "Helicopter in Air Transport" was presented at the February 24 meeting. Vice-Chairman Alfred L. Wolf presided, with 40 persons present.

▶ **Cost Comparison**—The paper, by James G. Ray, Air-line Consultant, who was instrumental in setting into operation four air lines—Eastern, All American Aviation, Southwest Airways, and a military branch operated by Air Transport Command—and who for many years was a member of the Pitcairn organization, centered about a cost comparison of the helicopter and conventional aircraft in either a cargo or passenger carrying capacity.

Helicopter costs, he said, are naturally still high, but for short hauls there is a definite saving in time, and in one application, at least—a mail line in Los Angeles—the use of helicopters has been extremely successful.

San Diego Section

W. T. Immenschuh, *Secretary*

On January 21, members of the Section were guests aboard the aircraft carrier U.S.S. "Boxer."

The carrier put to sea and about 10 a.m. called for air operations. A group of Douglas AD-1 and Grumman F8F planes were launched both by catapult and normal deck take-offs.

▶ **Target Planes**—Following this demonstration, radio-controlled aerial target planes were launched from a small speed boat that came out to meet the carrier from the shore. Demonstrations of aerial attack and defense resulted in the shooting down of the target planes as they approached the carrier in a strafing run.

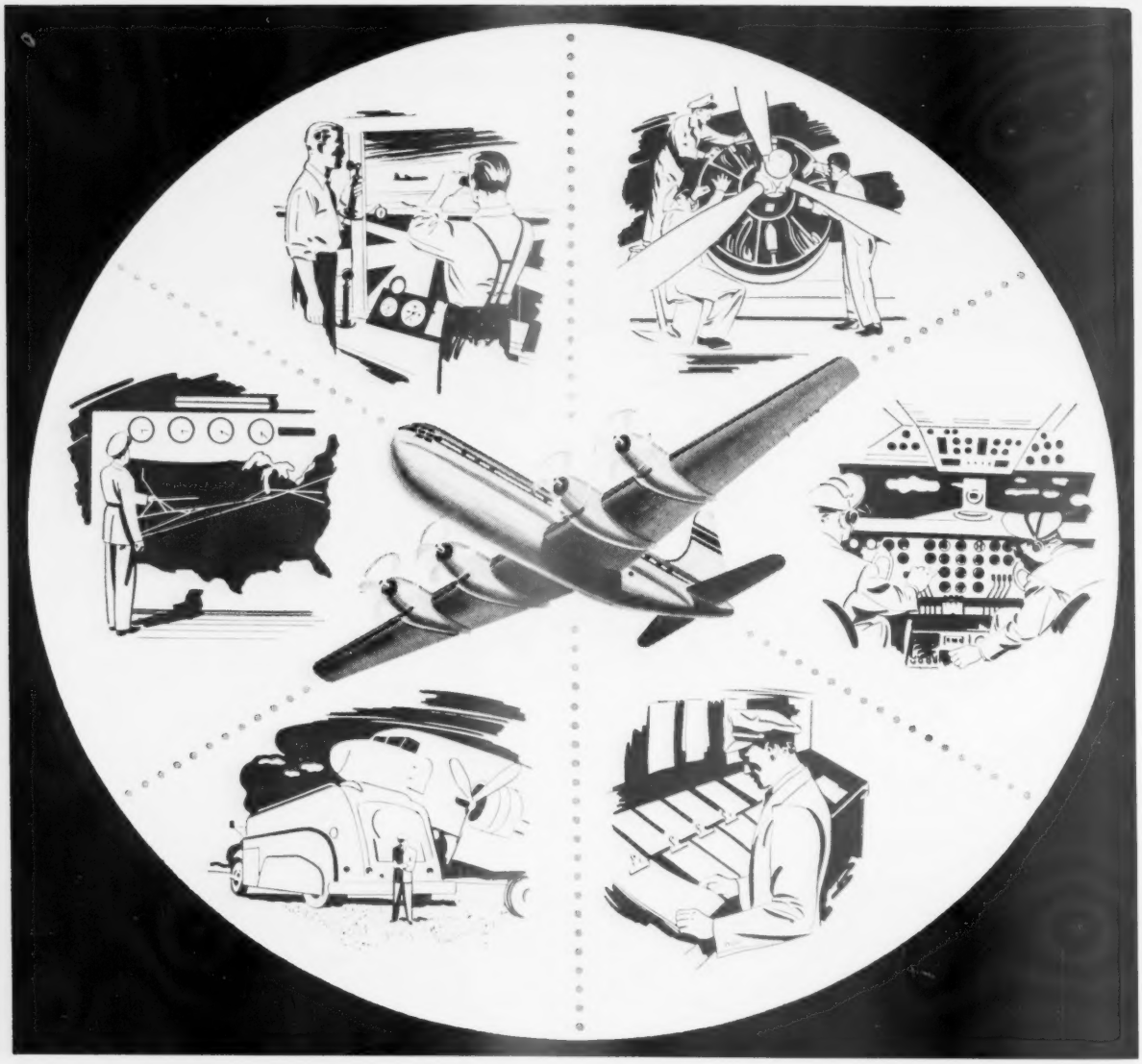
After lunch, air operations were continued with take-offs and arrested landings of several Bearcat fighter planes.

Every member was given the opportunity to inspect the ship, visiting everything from the engine room up to the crow's nest.

▶ **See for Themselves**—Approximately 90 members were able to see

San Diego Section, Carrier Field Trip

Aboard the U.S.S. "Boxer", January 21, 1949



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Seattle Section

Robert M. Robbins, *Secretary*

The Berlin Airlift was the subject of talks by two Air Force officers at the February 8 meeting. There were 125 persons present, with Chairman C. T. Steele presiding.

▸ **Airlift Training**—Lt. Col. Charles Downer discussed the training program for Berlin airlift replacement pilots being conducted at the Great Falls Air Force Base in Montana, while Captain Claude Haigler spoke on the operation of the lift itself.

Colonel Downer said the training program consists of 1 week of ground school, followed by 2 weeks of flying, alternated with ground-school work.

The flying program he stated, consists of 20 hours actual flying time, which is considered the bare minimum necessary to cover the required material. This 20 hours is divided into five missions of 4 hours each. During this time 22 landings are made, eleven of which are at the high gross weights used in Operation Vittles.

Purpose of the first mission of the five is to familiarize the pilots with C-54 type aircraft. The second consists of general instrument flying practice and GCA (Ground Control Approach) familiarization. The third is automatic direction-finder familiarization with emphasis on the oral-null method of orientation along with GCA practice. The fourth mission concerns itself with familiarization of procedures actually used in the corridors flown in the airlift operation. These procedures are actually simulated at the Great Falls Base. The final mission is the checkout ride; if successfully completed, the pilot gets a white instrument card. If he fails, he becomes a copilot.

There are at the Air Base 1,000 permanent personnel and 350 students at all times.

▸ **No Second Try**—Captain Haigler, who was with one of the first C-54 groups in the Berlin Airlift to replace the C-47's, described operations on the lift.

Because of the close separation, he said, it was mandatory that the air traffic procedures be adhered to rigorously. GCA was used for instrument let-downs and was used with only 3-min. separation of aircraft on landing. If an airplane missed an approach at Berlin, there was no second try. The pilot was required to climb back up and return to his base. If he missed an approach at the home base, it was probable he would be required to pull up and circle for 2½ hours, waiting for his next opportunity. This was all required because of the extremely dense traffic and because just one missed approach would upset the whole operation if the pilot was allowed to make another try immediately.

Air Force Night Speakers: *Washington Section members observed Air Force Night at their meeting March 8. Honorary Chairman of the meeting was Major Gen. E. M. Powers, Deputy Chief of Staff for Materiel, Hq. U.S.A.F. (third, left). With General Powers are (left to right): Col. Richard F. Bromiley, Executive, A.T.C., Hq. M.A.T.S., who spoke on the "Berlin Air Lift"; Brig. Gen. Donald L. Putt, Director, Research & Development, Air Materiel Command; General Powers; Col. Jack Taylor, All-Weather Flying Division, Air Materiel Command, speaker on "All-Weather Air Routes"; Col. Benjamin G. Holzman, Chief, Geophysical Science Branch, Research Division, U.S.A.F., who gave "Meteorological Research Horizons in the U.S.A.F."; and Lt. Col. Norman C. Appold, Chief, Propulsion Branch, Research & Development, Hq. U.S.A.F., who spoke on "Air Force Power Plants." General Powers opened with the remark that he knew of "no other civilian group that did more to further the war effort, cooperated more wholeheartedly with the Armed Forces, or made more valuable contributions to the achievement of victory in the last war than the men associated with the Institute." The meeting was preceded by a dinner at the Hays-Adams House in Washington.*

▸ **No Overt Actions**—Captain Haigler said Russian aircraft frequently would fly formation with the C-54's and do aerobatics in their vicinity, but there were no overt actions so far as he experienced.

The pilots had orders to ignore the Russians if they were in the corridors, but to obey them if they were not. Captain Haigler stated that when a C-54 did get lost out of the corridor, the Russian practice seemed to be merely one of flying alongside and motioning it back into the corridor.

Coal dust appears to be the major maintenance problem; it gets into all the systems of the airplane. In spite of the problems, however, aircraft utilization is about 11.6 hours per day.

Toronto Section

F. H. Brame, *Secretary*

As a result of a recent election of officers and Advisory Board of the Section, the following new officers have been selected:

Chairman, J. C. Floyd; Vice-Chairman, C. V. Lindow; Secretary, F. H. Brame; Treasurer, K. M. Molson. The Advisory Board is composed of B. J. Bourchier, Bernard Etkin, Richard Hiscocks, D. M. Holman, and W. U. Shaw.

Membership Committee members are: C. V. Lindow, W. U. Shaw, and F. H. Brame; Program Committee: Bernard Etkin; Nominating Committee: R. D. Hiscocks and D. M. Holman.

Washington Section

Ralph F. Broberg, *Secretary-Treasurer*

Commander Frank A. Erickson, Head, Rotary Wing Development Unit, U.S. Coast Guard, was Honorary Chairman at the February 8 meeting. Topic for the meeting, at which 150 members and guests were present, was "Development of Helicopter Flight Testing," a paper delivered by Raymond B. Maloy, Chief, Flight Engineering Division, C.A.A.

▸ **Three Main Phases**—Mr. Maloy's paper concerned itself with three main phases of helicopter development: ascertaining pilot requirements and pilot training; development of desirable operational technique; and deter-

mination of proper airworthiness requirements.

The history of C.A.A. helicopter flight-testing program began in the latter part of 1944, he said, when arrangements were made with the Air Force for the loan of a Sikorsky YR-4B.

At the conclusion of Mr. Maloy's paper, John P. Reeder, Engineering Test Pilot for the N.A.C.A., gave some prepared comments on the different approach to the problems employed by N.A.C.A. Additional comments also were made by John Mazur, Helicopter Project Engineer, U.S. Naval Air Test Center, Patuxent River, and Frank Piasecki, President, Piasecki Helicopter Corporation.

At the conclusion of the meeting, Commander Erickson presented some motion pictures of helicopter development work accomplished by the Coast Guard in the past 5 years.

Student Branches

University of Alabama

The third meeting of the winter quarter was held February 22 with 35 members present. Thomas Meledy, Chairman, presided.

The chief speaker was Dr. Eric Rodgers, Professor of Physics and Department Head of the university, who talked on the subject, "Einstein's Special Theory of Relativity." He discussed the historical aspects of the development of the theory and gave an elementary explanation of the special theory.

Cal-Aero Technical Institute

The January 28 meeting had 193 members present, with Chairman Albert Amaya presiding.

Mr. Amaya introduced K. L. Herrmann of the Herrmann Engineering Company as guest speaker on the subject, "The Herrmann Cam-Engine."

The speaker began his talk by classifying the various types of unorthodox engines, such as Watt's and Hall's crankless engines and McCumber's Wobbler Engine. Mr. Herrmann pointed out that the reason it is so difficult to design an unorthodox type of engine is that there is little experimental data available.

Comparisons between the Herrmann Cam-Engine and orthodox reciprocating engines were made by means of graphs of gas pressures, reciprocal forces, and piston-pin loads.

The various interesting points concerning the cam-engine, such as the 2:1 "built-in" reduction ratio and the twelve power strokes per shaft revolution, resulting in "uniform torque," were emphasized by its inventor. A total of 200 hp was expected to be obtained from the present engine, Herrmann said. He claimed that the engine cost less than half the cost of an orthodox engine to produce and that it cut regular manufacturers' equipment cost by 25 per cent.

Carnegie Institute of Technology

A tour of testing facilities at Air Materiel Command, Wright Field, was made March 11, Chairman George E. Bayuzick heading the party.

Catholic University of America

Chairman Marcian A. Herman opened the meeting February 16 with a welcome to new members. Mr. Seamone, of the program committee, then introduced the speaker, S. A. Gordon, Chief of Structures Section, The Glenn L. Martin Company, who gave a talk on "Relationship of Structural Testing of Aircraft Design." A film, *Structural Testing of the Martin 2-0-2*, was shown with the talk.

At the March 2 meeting, the speaker was Julian D. Maynard, of Langley Aeronautical Lab, N.A.C.A., who spoke on "The Effect of Ice, and Heated Air Deicing on the Aerodynamic Performance of Propellers."

University of Colorado

A combined meeting was held February 2 with the S.A.E., Robert M. Wood, Chairman, presiding. Professor K. D. Wood, Head of the Department of Aeronautical Engineering, reported on his trip to the I.A.S. Annual Meeting in New York.

Robert Naegele demonstrated flow patterns in a device prepared by Fred Kroll for his master's thesis. Polarized and doubly refracted light was passed through a suspension of bentonite particles in water. The diffuser angle was variable, as was the velocity. Turbulence and flow patterns around various wing shapes was shown.

On March 3 members were guests of the A.S.M.E. at which R. C. Treseder, of General Motors, presented a talk on propellers.

Cornell University

"Measurements of Isotopic Turbulence" was the title of a talk given by Dr. H. W. Liepmann, Professor of Aeronautics, Cal-Tech, at the February 8 meeting. Chairman Franklin Moore presided.

Louisiana State University

At the February 17 meeting, J. E. Douglas was appointed to fill the vacancy of chairman of the Film Committee left by the graduation in February of former incumbent, J. R. Delk.

Massachusetts Institute of Technology

New officers were elected at the February 9 meeting as follows: Chairman, Charles E. Richbourg; Vice-Chairman, Donald P. Germeraad; Secretary-Treasurer, Anthony J. Navoy.

A film, *Working on Air*, was shown before the meeting was adjourned.

As part of the program to acquaint M.I.T. freshman with the facilities available at their school, the Aeronautical Engineering Department held "open house" during the week of February 7–11. It consisted of conducted tours through some of the aeronautical laboratories and various exhibits sponsored by student activities connected with the field of aviation.

The program was sponsored and planned by members of the Branch. Professors Walter Gale and Holt Ashley acted as Faculty Advisors to the Program Planning Committee, which consisted of George Haviland, Otto Kirchner, Gaetano Falabella, and Lewis Roosa.

University of Michigan

The field trip to Wright-Patterson Air Base and testing laboratories on March 14 was attended by 55 students. The tour of the testing and experimental laboratories was of great interest to students in all branches of aeronautical engineering because all ramifications of aircraft testing are conducted there.

There are several wind tunnels at the base, including a vertical tunnel for parachute testing and spinning characteristics. A ram-jet engine was run for the visitors, who also saw the methods used by the static testing laboratory in testing an improved wing fastening for the B-36. Latest developments in radio, radar, photography, fire detection, flight clothing, and many other items were also shown.

University of Notre Dame

On February 24 plans for the ensuing semester were laid out by the new

(*Continued on page 91*)

News of Members

W. H. Beardslee became Sales Manager for the Hansen-Lynn Company early last February. He formerly was with the Burklyn Company of Los Angeles in charge of Aircraft Sales. Hansen-Lynn's home office is at 800 S. Flower St., Burbank, Calif.

Norman R. Beers is Editor, *Nucleonics* for the McGraw-Hill Publishing Company, New York City. He formerly was Leader, Meteorology Group, Nuclear Reactor Project, Brookhaven National Laboratory, Associated Universities, Inc., Upton, N.Y.

Robert O. Bitner is Stress Analyst and Design (Mechanical) Engineer, Engineering Division, Wind Tunnel Branch, Air Materiel Command, Wright Field, Dayton, Ohio. He was appointed January 3 and lives at 1716 Leo St., Dayton.

Walter Brandle recently resigned his position with The Glenn L. Martin Company to accept the position of Layout Draftsman in the Design Section of Reaction Motors, Inc., Dover, N.J., builders of rocket engines.

Ward Brannon, who resigned from The Glenn L. Martin Company last December, is Aerodynamicist "A" at Northrop Aircraft, Inc. New address is 3281 Sepulveda Blvd., Los Angeles 34, Calif.

Robert H. Broker has been transferred to the Dallas plant of Chance Vought Aircraft Division, United Aircraft Corporation, from Stratford, Conn. New address is 3804 Stratford, Dallas, Tex.

Marvin M. Brown is Assistant Field Engineer for The Stapp Engineering Company; his address is 611 North Fifth, Gallup, N.M.

Professor Robert L. Champion, who has been President of Aviation Facilities Associates, Inc., since June, 1946, reports he also has been Professor of Airways Design, ITA. He is in Rio de Janeiro, Brazil—address: Cocta, Sala 315, El Nova Estacao de Passageiros, Aeroporto Santos Dumont.

Adam Craigon is Aeronautical Projects Engineer, Messrs. Margison & Babcock, Consulting Engineers, at 119 Isabella St., Toronto, Ontario, Canada. He was Engineering Director, High Speed Motors Corporation Ltd. in Toronto.

Charles H. Crispin, who had been in Brazil in the Escola Technica de Aviacao, Sao Paulo, is now with Gordon B. Kaufmann & J. E. Stanton, architects, Los Angeles, Calif. New address is 1107 South Bronson Ave., Los Angeles 6.

Norman W. De Carteret is Industrial Engineer at Stanford Research Institute, a consulting organization; new home address is 151 Melville Ave., Palo Alto, Calif.

Louis J. Demer is Assistant Professor of Materials Engineering, Department of Materials Engineering, College of Applied Science, Syracuse University. He had been an Engineer with Murray Company, Honesdale, Pa.

Arthur F. Deming is Consulting Engineer in Dynamics, sub- and supersonics, for Hughes Aircraft Company. Address is 23,205 Maribel, Avalon Village, Wilmington P.O., Calif.

Thomas B. Doe resigned as President of The Sperry Corporation last February. He is continuing his position as a Director and will remain in the regular employment of the company as a Consultant.

Christopher Dykes has been promoted by British Overseas Airways Corporation to Assistant Technical Development Director (Engineering). He previously was Chief Project Engineer.

Nathan J. Frank has accepted temporarily a position as Aviation Metalsmith at the Navy Air Test Center, Patuxent River, Md.

Everett A. Hannifin has been Vice-President and Chief Engineer of The Versatool Corporation, Hartsdale, N.Y., since January. He had been Engineering Instructor in The Aeronautical University, Chicago. Home address is 204 Old Colony Rd., Hartsdale, N.Y.

George N. Jones, former Sergeant, U.S.M.C., Engineering, has been promoted to Staff Sergeant.

James B. Jones, formerly Layout Draftsman with Piasecki Aircraft, has been with H. L. Yoh Company the past several months in the same capacity. Address is 151 Ohio Ave., Absecon, N.J.

W. H. Kearns-Batchelor has been Maintenance Supervisor of the Canadian Breweries Ltd. for the past year. He formerly was Flight Engineer.

GOODYEAR DIRECTOR

Ralph S. Damon has been elected, and since approved by the Civil Aeronautics Board, a Director of the Goodyear Tire & Rubber Company. Mr. Damon, an I.A.S. Fellow and President of Transcontinental & Western Air, Inc., succeeds Thomas E. Wilson, Chairman of Wilson & Company, who resigned as a Goodyear director. Formerly President of American Airlines, Mr. Damon is a trustee of New York Trust Company and President of the Board of Trustees of Clarkson College of Technology.

Stuart M. Levin is with Fairchild Engine & Aircraft Corporation, Washington, D.C., as a Structural Engineer.

Robert W. Lilligren, who was Development Engineer, Wayne Pump Company, has been Design Engineer for the Rhodes Lewis Company for the past several months.

Sidney L. Kent, Spartan School of Aeronautics graduate, is with the Gas Turbine Engineering Division of A. V. Roe Canada Ltd. as a Test Engineer. He lives at 71 Forest Hill Rd., Toronto, Ontario, Canada.

Saul Knoblock was promoted by the Navy Department from Aeronautical Engineer P-5 to Aeronautical Engineer P-6, and transferred to Chance Vought Aircraft Division in Dallas as the Bureau of Aeronautics Representative. He had been at Curtiss-Wright (Columbus) as BuAer representative.

Peter G. Masefield is Assistant Chairman and Chief Executive of British European Airways, Keyline House, Northolt Airport, London, England.

Colin H. McIntosh is Director of Operations, All American Airways, Inc., located at Washington National Airport, Hangar 12, Washington, D.C.

Thomas A. Morgan was elected President of The Sperry Corporation following the resignation of Thomas B. Doe in February. Mr. Morgan is retaining his position of Chairman of the Board.

Robert B. Phillips, formerly Teacher of Aeronautics at Landon High School, Jacksonville, Fla., has been appointed Instructor for National Airlines, Inc., and is now residing in Miami. His new duties involve instruction in flight operations and associated subjects.

Rodger F. Ringham, Chance Vought Aerodynamics Engineer, has moved with the firm to Dallas, Tex.

Commander J. P. Sager, U.S.N., has been assigned to the Overhaul and Repair Department, Production Division, Naval Air Station, Alameda, Calif.

D. G. Samaras has become Senior Research Engineer, Office of Air Research, Jet Propulsion, Air Materiel Command, Wright Field. He was with the National Research Council, Ottawa, Canada, until the first of February.

Donald F. Samhammer, formerly with The Glenn L. Martin Company as Aeronautical Engineer, is Aeronautical Engineer Draftsman "A" at Fairchild Engine and Airplane Corporation.

William C. Schoolfield's new address is 5556 Emerson Ave., Dallas 9, Tex. He went along with Chance Vought to its new plant in the Lone Star State, where he is Chief of Aerodynamics.

Jerome M. Schwarzbach resigned as Aerodynamics Engineer, Pilotless Plane Division, Fairchild, to become Project Engineer, Flight Test Division, Naval Air Test Center, Patuxent River, Md., last February 3.

Dr. S. R. SenGupta was named Principal of the Bengal Engineering College, Botanic Garden P.O., Howrah, West Bengal, India.

(*Continued on page 92*)

I.A.S. HONORARY FELLOW FOR 1948—CAPT. JOHN LAURENCE PRITCHARD, Secretary, Royal Aeronautical Society

Author and journalist; writer on scientific subjects and aeronautics; joined Royal Fusiliers as private, 1915; transferred to Admiralty R.N.A.S., 1916; transferred to Air Ministry, 1918; retired with rank of captain, 1919; Editor, *Journal of the Royal Aeronautical Society*, since 1920; Technical Editor, *Wireless Encyclopaedia*, 1923–1924; Honorary Fellow, Royal Aeronautical Society; Honorary Fellow, Institute of the Aeronautical Sciences.

Publications: *Aeroplane Structures*, with A. J. S. Pippard, 1920 (new edition, 1935); *Broadcast Reception in Theory and Practice*, 1926; *The Story of the Aeroplane*, 1927 (third edition, 1935); Technical Editor, *Handbook of Aeronautics*, 1931; also many works of fiction on crime and criminology.

Editorial

Welcome, R.Ae.S.—!

In the Spring of 1945 it was our privilege to attend a luncheon, at the Royal Aeronautical Society in London, in honor of Dr. T. P. Wright, Wilbur Wright Memorial Lecturer for that year. Hanging over the speaker's table was the smoke-blackened, bomb-torn flag that had flown over No. 4, Hamilton Place during London's Ordeal by Fire. As the luncheon ended, the President of the Society formally presented this symbol of Britain's survival to the Institute as a memento of the common interest and mutual good will that exists between the two societies.

Once again, representatives of England's aeronautical society will gather under that historic flag. Too fragile to be exposed to the hazards of New York weather, it will be hung in the foyer at 2 East 64th Street, to welcome the delegates from the Royal Aeronautical Society assembled for the second international conference between the two societies. Once again, it will be a reminder of continuing collaboration for the common good among men of like minds on both sides of the Atlantic Ocean.

Readers of the REVIEW are by now familiar with the plans for the 2-week program. After 3 days of technical sessions in New York's Hotel Astor, the British delegation will be taken on a tour of some of the points of aeronautical interest along the Eastern Seaboard. It is to be regretted, of course, that limitation of time and of travel funds will make it impossible to visit all areas of aeronautical activity in the United States. Some of the party may stay on for more extended visits in connection with their own business activities, but it was necessary, largely for financial reasons, to limit the travel program for the group as a whole.

We hope that every I.A.S. member will do everything possible to make our visitors' time in America pleasant and profitable. Those of us who went to England in September, 1947, for our first Anglo-American Meeting have not forgotten the hospitality that was extended by our colleagues overseas. We are now glad to be in a position to retaliate in kind.

We trust that every member of the Institute who can do so will participate in the 3 days of technical sessions in New York. The primary purpose of the joint conference is to exchange current technical information between Great Britain and the United States. An excellent program, with important papers by a group of top-flight British and American engineers, has been put together. They bring to a common focus the current thinking on the latest aspects of the aeronautical arts from both sides of the Atlantic. By attending the sessions and by participating in the discussions, we can all contribute to the pool of common knowledge in the aeronautical sciences that may, in the long run, prove to be our ultimate salvation.

We welcome our friends from overseas. We hope that this coming meeting will be another strong link in the chain that binds our countries together. We hope that we may be privileged to continue these meetings for the exchange of views on subjects of mutual interest for many years to come.

S. P. J.

Flight Propulsion

Summary of Technical Sessions at Cleveland, March 18

Compressors and Turbines in High-Pressure Ratio Power Plants

By

Robert O. Bullock

The Fourth Annual Propulsion Meeting, sponsored by the Cleveland-Akron Section of the Institute was attended by more than 500 leading experts in the field of gas-turbine power plants and aircraft propulsion. The papers presented during the all-day meeting were devoted to a discussion of some of the outstanding problems associated with the attainment of the high-pressure ratio high-temperature power plants presented by Abe Silverstein in his Twelfth Annual Wright Brothers Lecture.

Four papers discussing the role to be played by compressors and turbines in the high-pressure ratio power plants of the future were presented at the Morning Session. The first paper was entitled "Multi-staged Centrifugal Compressors for Operation at High-Pressure Ratios." This paper was prepared by John E. Talbert, Assistant Engineering Manager, and John E. Sanders, Assistant Project Engineer, Research Division, Engineering Department, Wright Aeronautical Corporation; it was presented by Mr. Talbert. Russell S. Hall, Engineer, Aircraft Gas Turbine Division, General Electric Company, then presented the paper entitled "Aerodynamic Problems in Axial Compressors for Aircraft Jet Engines." In the third paper of the morning session, John W. Blanton, Chief of Fluid Dynamics, Engineering Power Division, Fredric Flader, Inc., discussed "High Pressure Applications of the Supersonic Compressor." Finally, "The Choice of Pressure Ratio in Aircraft Gas Turbine Power Plants" was discussed by Prof. C. Richard Soderberg, Head of Mechanical Engineering Department, Massachusetts Institute of Technology.

Eugene Wasielewski, Chairman of the Cleveland-Akron Section of the Institute of Aeronautical Sciences, called the meeting to order, and W. A. M. Burden, the President of the Institute, gave a short welcoming address. Mr. Wasielewski then introduced the Chairman of the Morning Session—Ronald B. Smith of The M. W. Kellogg Company. After explaining the main theme of the papers of the morning session, Mr. Smith introduced the first speaker, John E. Talbert.

Mr. Talbert compared the computed performance and estimated mechanical complexity of several methods of compounding centrifugal compressors. He discussed the many design factors involved and

showed that for pressure ratios about 10 to 1, the overall efficiency does not vary appreciably. He concluded therefrom that the design of such a multistaged centrifugal compressor should be governed more by the considerations of weight, mechanical complexity, and number of stages rather than overall efficiency.

In presenting his paper, Mr. Talbert noted first that the benefits to be attained by continued increases in permissable turbine-inlet gas temperature could be realized only by simultaneous increases in compressor pressure ratio. He then cited the durability and ease of manufacture of the centrifugal compressor and voiced the opinion that these desirable features merited the centrifugal compressor at least some consideration for high-pressure ratio engines. Mr. Talbert then mentioned that, although his analysis included compressor pressure ratios up to 50 to 1, most of his comparisons were made at the pressure ratio of 20 to 1.

In making the calculations, it was assumed that optimum compressor matching was obtained at each pressure ratio and design configuration considered. It was also assumed that the variation of the efficiency and pressure ratio of an individual compressor with tip speed would be the same as that observed on typical centrifugal superchargers. This assumption was felt to be conservative because of the comparatively small size of the reference supercharger impellers (13 in. in diameter). It was finally assumed that the interstage losses would be proportional to the density and be equal to $1^1/_2$ in. of mercury for sea-level static inlet conditions.

With these assumptions Mr. Talbert studied the performance of a staging arrangement in which compressor impellers of the same diameter were mounted on the same shaft. It was found that a pressure ratio of 20 to 1 could be obtained from a four-stage unit when the top speed was 1,300 ft. per sec. When the tip speed was 1,100 ft. per sec., however, the maximum pressure ratio that could be produced by five stages was 17 to 1. Although the efficiency of each individual compressor was greater at 1,100 ft. per sec. than at 1,300 ft. per sec., the accrued interstage losses caused the overall efficiency at the lower speed to be less than 1 per cent greater than that at the higher speed when the overall pressure ratio exceeded 10 to 1. The efficiencies varied from approximately 72 per cent at a pressure ratio of 10 to 1 to approximately 68 per cent at a pressure ratio of 40 to 1. Because of the trivial difference in efficiency, considerations of complexity favored the higher tip speed. Mr. Talbert also studied a geared arrangement giving a pressure ratio of 28 to 1 in four stages and a free wheeling arrangement giving constant pressure ratio per stage. At pressure ratios above 10 to 1, there was again but trivial differences in the relative overall efficiencies. When the efficiency of the individual compressors was assumed to be increased 5 per cent, there was only a small change in the overall efficiency. Again, doubling the magnitude of the interstage losses decreased the overall efficiency only 2 per cent at a pressure ratio of 17 to 1. Since the efficiency of a high-pressure ratio centrifugal compressor staging arrangement appeared to be only slightly affected by the configuration of the arrangement, Mr. Talbert reached the conclusion that the mechanical complexity of a given arrangement should govern its selection for practical applications. In general, the complexity will increase with the number of stages, since the problems of sealing, critical speeds, and weight increase with the number of stages. The problems associated with the use of gears and concentric shafts were also deemed to be of primary importance.

Mr. Talbert noted that he had tacitly assumed that each of the compressor components would satisfy the laws of geometric and dynamic similarity and that the complete realization of these laws would be impossible in a practical unit. He showed, however, that the errors thus introduced would probably be small. He also noted that a design for optimum operation at design speed would generally have to be tempered to avoid surging at starting or idling speeds.

It was emphasized that the calculations had all been made for the condition of no intercooling. Although intercooling would greatly improve the apparent efficiency of the compressor assembly, it was felt that the mechanical and aerodynamic complications thus introduced would more than nullify the benefits.

In conclusion, Mr. Talbert described the experimental equipment used by the Wright Aeronautical Corporation for developing its multistaged centrifugal compressors. A test unit utilizing a vaneless diffuser for impeller development was described. A vaned diffuser experimental rig for developing an impeller, vaned-diffuser combination was then discussed. Finally, the experimental rig for investigating the performance of a two-stage centrifugal compressor assembly was presented.

Hurst Davis, of the Elliot Company, began the discussion by questioning Mr. Talbert's decision that the question of dynamic similarity would have only small effects on the results he presented. For the case of

Morning Session Speakers *(left to right)*: Eugene Wasielewski, Chairman of the Cleveland-Akron Section; Ronald B. Smith, The M. W. Kellogg Company, Chairman of the Session; John E. Talbert, Wright Aeronautical Corporation; R. S. Hall, General Electric Company; John W. Blanton, Fredric Flader, Inc.; and C. Richard Soderberg, Massachusetts Institute of Technology.

several compressors of the same diameter rotating on the same shaft, he pointed out that the specific speed of the first-stage compressor would be much higher than that of the final stage. A general deterioration of efficiency from the first to the last stage would be therefore expected. Mr. Davis also emphasized Mr. Talbert's acknowledgement that part load characteristics would be difficult.

Mr. Robinson, of Sanderson and Porter, then stressed the fact that economics of manufacturing were in favor of the centrifugal impeller, particularly when production of gas-turbine engines on a large scale was demanded. He also noted that Mr. Talbert's assumptions of efficiency being based on impellers 13 in. in diameter were extremely conservative, inasmuch as there was ample evidence to show that efficiency increased as the size, or Reynolds Number, increased. Since the Reynolds Number of the latter stages would be higher than that at the first stage, the efficiency of the latter stages would tend to increase, a trend that would oppose the trend discussed by Mr. Davis. Mr. Robinson stated, however, that it was difficult to see an assembly consisting of more than three stages. He mentioned that a practical multistaged assembly of the future might have, as a first stage, one of the high flow capacity mixed-flow compressors now being developed.

D. G. Samaras, of Air Materiel Command, Dayton, Ohio, recalled some studies in which he participated during 1943. One of the prime conclusions of these studies was that high-pressure ratio cycles were the optimum for long-range flights.

William E. Trumpler, of Clark Brothers, Inc., disagreed with Mr. Davis' statement that compressor efficiency is compelled to deteriorate as the specific speed is reduced. He cited comparatively low specific speed compressors developed by his organization as examples and stated that the efficiency of these compressors was stable over a wide range of operating conditions.

Mr. Talbert, in reply to Mr. Davis' remarks, noted that increases in temperature accompanied increases in density as the flow progressed from stage to stage. The loss in efficiency accompanying a decrease in flow coefficient in the latter stages would thus be tempered by the tendency of the lower equivalent tip speed to raise the efficiency.

In an interesting paper on axial-flow compressors, Mr. Hall presented his audience with three problems: (1) the problem of pulsation, (2) the problem of nonvortex stages, and (3) the problem of limiting critical Mach Numbers. In presenting these problems he showed that improvements in jet engines in terms of specific fuel consumption, engine weight per pound thrust, and thrust per square foot of frontal area depend primarily on increases in overall pressure ratios, increases in weight flows per unit of frontal area, and increases in pressure ratio per stage (i.e., small weights). Assuming a pressure ratio of 10 to 1 as a goal, it was pointed out that the problem of improved efficiency was not considered so vital as the aforementioned three problems, since it was difficult to obtain sensible improvements in engine performance by increasing axial compressor efficiency above that now attainable.

Mr. Hall then discussed the problem of pulsation ("a compressor with the hiccoughs"), which assumes prime importance at starting and intermediate speeds.

A simple analysis was then presented to demonstrate that the difficulties imposed by pulsation become increasingly severe as the overall pressure ratio is increased. This analysis simply assumed that the weight flow at pulsation was proportional to the speed, while the pressure ratio was proportional to the square of the speed and a compressibility factor. The pressure ratio at pulsation was thus roughly proportional to the square of the speed. On the other hand, the weight flow through the turbine may be roughly assumed to be directly proportional to the compressor pressure ratio for a given turbine inlet temperature. If optimum compressor and turbine performance is to be obtained at the design point, the turbine curve thus must cut through the pulsation line at some intermediate speed. As the pressure ratio is increased, the turbine curve must extend further and further beyond the surge line. Mr. Hall stated that, up to pressure ratios of 6 to 1 or 8 to 1, the designers might be able to cope with the problem in the same manner as they do now—by evading it and deliberately mismatching the compressor and turbine at the design point. At higher pressure ratios however, the efficiency loss resulting from the mismatching would be prohibitive. Mathematical or empirical analysis of the pulsation phenomenon is urgently needed in order to cope with the problem. Mr. Hall noted that this analysis should include both single and compound compressors.

The advantages and problems of the nonvortex stage were then discussed. It was shown that, although the vortex stage presents the minimum analytical difficulties, the inherent high tangential velocities at the hub impose a minimum limit on the ratio of hub to tip diameter at the compressor inlet. As a consequence of this limitation, an upper limit will be imposed on the weight flow per unit frontal area. On the other hand, efficiency considerations impose a maximum limit on the ratio of hub to tip diameter near the compressor outlet. The vortex stage thus imposes a limit on the amount by which the flow area may decrease between the inlet and outlet of the compressor. With the present limits on axial velocity at the compressor inlet, the limitation on area ratio will cause the axial velocity in the latter stages of a high-pressure ratio compressor to be extremely low. The pressure ratio per stage will therefore be low in the latter stages. As a consequence, the compressor will be long and heavy. The gains that could be achieved, both in mass flow per unit frontal area and in inlet to outlet area ratio by various deviations from a vortex stage at the compressor inlet, were then shown.

By presenting the pertinent implications of the Nanier-Stokes equation, the continuity equation, and the vorticity equation, Mr. Hall outlined the difficulties in analyzing the flow through a nonvortex stage. He showed that one of the difficulties was analogous to the down-wash associated with airfoils of finite span. The other important difficulty stemmed from radial equilibrium. The analyses of Frank E. Marble, of the California Institute of Technology, and C. H. Wu and L. Wohlfenstein, of the Lewis Laboratory of the N.A.C.A., were cited as significant contributions to the nonvortex problem, but techniques for obtaining more complete solutions were eagerly awaited, since this problem was probably the most vital of the three.

Mr. Hall then noted increases in both airflow per unit frontal area and pressure ratios per stage would accompany increases in the limiting critical Mach Number. Although research (particularly the development of conformal mapping techniques) is expected to increase the maximum Mach Number for which tolerable efficiencies can be obtained, the gains that can be obtained in a completely subsonic compressor are limited. The completely supersonic compressor, however, did not appeal to Mr. Hall as the solution to the problem. The minimum value of the ratio of hub to tip diameters appears to be limited by the requirements of high Mach Numbers relative to the blade. The losses occasioned by the interaction of shock and boundary layer within the compressor blades tend to preclude the possibility of attaining compression efficiencies comparable to those now obtained in several subsonic stages. Finally, the high tip speeds required by the latter stages of a completely supersonic compressor (because of the high temperatures) present a difficult turbine matching problem. Mr. Hall then suggested the use of what he called a transonic compressor, one in which the flow was supersonic at the tip and subsonic at the hub. To those who would be appalled at the idea of deliberately mixing subsonic and supersonic stresses, Mr. Hall offered the comforting remark that the several opposite characteristics of the two streams might enable one régime to be a cushion for the other. In any event, it is an interesting problem embracing the entire field of aerodynamics.

Seymour H. Bogdonoff, of Princeton University, initiated the discussion by suggesting that untenable changes in axial velocity would result from the combined use of small hub-tip diameter ratios and nonvortex stages. He also reported studies of the pulsation phenomenon, which indicated that pulsation occurred when several of the early stages stalled at approximately the same flow condition. Dr. Andrew Feyer, of Packard, then endorsed Mr. Hall's ideas on transonic compressors.

Dr. Von der Nuell, of AiResearch, considered the axial compressor to be at an economic disadvantage in comparison to the centrifugal type. He thought that the efficiency assumptions in the first paper were too conservative and that the contrast in efficiencies of the axial and centrifugal types were too marked.

D. G. Samaras, of A.M.C., thought that Mr. Hall's omission of the partial derivatives with respect to time invalidated the reported analysis.

Mr. Hall then commended Mr. Bogdonoff's researches on pulsation and noted that, if the complete radial equilibrium equations were considered, instead of the simple equation, Mr. Bogdonoff's worries of large axial velocity changes would disappear. In reply to Mr. Samaras, Mr. Hall stated that he did not intend for his analysis to apply during pulsation.

Mr. Blanton began his paper by remarking that supersonic compressors offered a method of simultaneously obtaining the high pressure ratio per stage and the simplicity of centrifugal compressors, as well as the airflow capacity and efficiency of axial-flow compressors. Defining a supersonic compressor as one having supersonic velocities relative to the inlet section of a row of blades, Mr. Blanton pointed out that many configurations of supersonic compressors could exist. As examples, he discussed three arrangements: (1) supersonic rotor and subsonic stator; (2) subsonic rotor and supersonic stator; and (3) supersonic rotor and supersonic stator. Because the attainment of large increments in tangential velocity components without separation was difficult with subsonic rotors, he believed that large pressure ratios per stage could be readily obtained only by the use of supersonic rotors. He then limited his discussion to supersonic rotors having a normal shock in the blades.

Four applications of supersonic rotors were then considered—a single-stage supersonic compressor, a multistage supersonic compressor, a supersonic compressor followed by a centrifugal compressor, and a supersonic compressor followed by an axial subsonic compressor. Mr. Blanton showed that a supersonic rotor followed by a subsonic stator may deliver pressure ratios as high as 5 to 1. A pressure ratio of 8 to 1 might be expected from the combination of a supersonic rotor and supersonic stator. When subsonic stators are used, a pressure ratio of $7\frac{1}{2}$ to 1 is obtainable from a two-stage compressor. The use of supersonic stators would raise the expected pressure ratio to $12\frac{1}{2}$ to 1; if intercooling were used, this pressure ratio would increase to 28 to 1. If the first stage were to have a supersonic stator and the second stage a subsonic stator, a pressure ratio of 10 to 1 would be expected. The combination of a supersonic compressor and centrifugal compressor would yield pressure ratios of the order of 12 to 1. A supersonic rotor followed first by a subsonic axial-flow rotor and then, by conventional subsonic stators and rotors, would provide pressure ratios between 5 to 1 and 20 to 1, depending on the number of stages used.

Mr. Blanton stated that he considered only the ideal shock losses in arriving at the reported results. He realized that the severity of these losses might be greatly increased if flow separation resulted from the occurrence of strong normal shocks. It was believed, however, that small diffusion rates behind the shock and careful design would alleviate this problem.

On discussing Mr. Blanton's paper, Mr. Hall stated that he was still convinced that the flow capacity, or "gulp factor," of the supersonic compressor was limited by the relatively small hub to tip diameter ratios required. Mr. Erwin, of the Langley Aeronautical Laboratory, N.A.C.A., pointed out that, although the supersonic compressor was still in its infancy, highly encouraging results had been obtained. Several exploratory compressors had equalled the efficiency of centrifugal compressors and the flow capacity of the best axial compressors, even though the latter variety had reaped the benefits of years of experience. Mr. Campbell, of the Wright Aeronautical Corporation, expressed the belief that the centrifugal, axial, and supersonic compressors had many outstanding common problems.

In reply to Mr. Hall's remarks, Mr. Blanton stated that future research should greatly improve the flow capacity of supersonic compressors.

Professor Soderberg's paper pointed out that the variables that most directly affect the performance of aircraft gas-turbine power plants are turbine inlet temperature and compressor pressure ratio. The former is determined chiefly by the materials available and the arrangements for blade cooling. A gradual increase in turbine inlet temperature may be expected as the art advances. The latter presents conditions of optimum circumstances which are the object of a well-rounded design. In most cases, however, the desired pressure ratio is still beyond the state of the art, the principle problems being related to the compressor. The present period of a rapidly changing art presents unusual circumstances, because the premises may be altered fundamentally during the development of a power plant. If the aim is set too low, the machine may be outmoded before it is completed; if it is set too high, it may never emerge out of the development stage. Professor Soderberg then discussed this problem for the turbojet and presented approximate curves of specific air and fuel flow for different pressure ratios, turbine inlet temperatures, and flight Mach Numbers.

The curves presented were approximate in the sense that ideal gases were assumed for the process. It was noted, however, that the agreement between the presented results and those obtained by more rigorous methods was sufficiently good to warrant their use as a thumbnail sketch of the situation. For each turbine inlet temperature there are specific pressure ratios associated with minima of both airflow and fuel flow. The minima for fuel flow occur at higher pressure ratios and are sharper than the minima for airflow. As the turbine temperature increases, the minimum air and fuel flows shift to higher pressure ratios and their values decrease. Increases of flight speed shift the entire group of curves to lower compressor ratios. Lower component efficiencies will generally increase both air and fuel consumption, and the minima tend to shift to lower pressure ratios.

The optimum choice of pressure ratio will lie somewhere between the region of minimum airflow and minimum fuel flow. This still leaves room for a wide range in choice, however. As an example, the case of 675 miles per hour at sea level was considered. For a ratio of turbine inlet temperature to ambient temperature ratio of 4, the minimum airflow occurs at a compressor pressure ratio of about 5.5; the minimum fuel flow occurs at a pressure ratio of about 17. The incentive for increasing pressure ratio for the single compressor to the limit is obvious. A divided compressor, permitting higher pressure ratios, must be justified by an evaluation of the relative value of the reduction in fuel consumption as against the increase of weight due to increased airflow and increased number of stages. The specific fuel consumption attainable for turbojets at extremely high speed were found to be surprisingly low. For example, at flight Mach Number 1.568, 35,000 ft. altitude and a turbine inlet temperature of 1,505°F., the optimum compressor pressure ratio is about 13. At these conditions fuel consumption of the order of 0.4 lb. per hour per hp. appears possible with jet engines.

In a prepared discussion, Oscar W. Schey, of the Lewis Flight Propulsion Laboratory, N.A.C.A., reemphasized the incentive for increasing the turbine inlet temperature and compressor pressure ratio, particularly for gas-turbine propeller engines. He presented curves to show that the gain in turbine propeller engine performance resulting from improvements in component efficiency was almost trivial in comparison to the gains offered by the higher temperatures and pressure ratios. He added that the N.A.C.A. was sparing no effort to provide the fundamental knowledge necessary to achieve these performances indicated by these analyses.

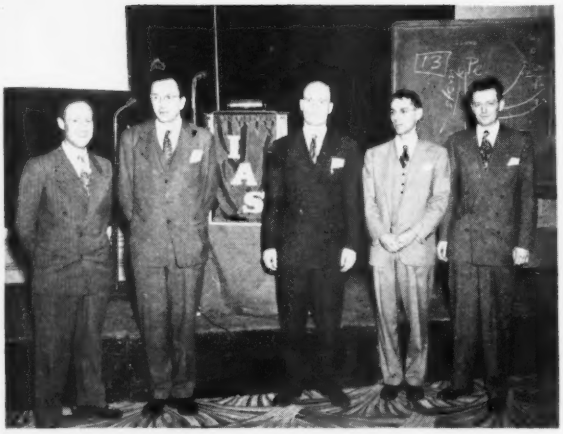
Aircraft Jet Engine Combustion

By
Dr. Walter T. Olson

THE AFTERNOON SESSION under the able chairmanship of Dr. A. G. Cattaneo of the Shell Development Company featured two papers on turbojet combustion, one on ram-jet combustion, and one on flame stabilization applicable to ram-jet or other systems. A significant characteristic of all four papers was the strong tendency to utilize basic data, such as static inflammability limits and laminar flame speed, to explain and to generalize combustion phenomena. This is gratifying to see in a field in which past progress has been dependent on the empirical approach.

A. J. Nerad, of the Research Laboratory of the General Electric Company, presented the first paper entitled "Some Aspects of Turbojet Combustion." This paper discussed the status of the turbojet combustor as a device incorporating several apparently simple features to perform a highly complex operation.

The main features of the combustors described by Mr. Nerad have, by and large, resulted from a long



Afternoon Session Speakers *(left to right)*: A. G. Cattaneo, Shell Development Company, Chairman of the Session; A. J. Nerad, General Electric Company; Stewart Way, Westinghouse Electric Corporation; F. P. Longwell, Standard Oil Development Company; and Glenn C. Williams, Massachusetts Institute of Technology.

program of cut-and-try development to obtain the highest performance in all respects. These features include a flame initiating or flame stabilizing zone, a special fuel injection nozzle for wide ranges of flow, and a dilution zone.

Undoubtedly the most important single characteristic of the combustor is the flame initiating or flame stabilizing zone—that is, the zone in the dome end of the combustor where flame anchoring and a smooth, continuous ignition process occur. This flame stabilizing zone is produced by a strong reverse flow of heated air and gas, called an "ignition eddy." It has been found that the strength of this backward flow, or eddy, may be controlled by various design factors, such as the location of holes and louvers in the wall of the flame tube, and that one-fourth of the total air should go into the ignition eddy for best results.

Because of the wide range of fuel flows required by the turbojet combustor, fuel nozzles of wide fuel-flow range are required. The so-called "duplex" nozzle has approximately four times the effective atomization range of the simple vortex nozzle for the same fuel-flow requirements and the same limiting fuel pressure and thus has proved extremely valuable. At the highest fuel flows, some liquid fuel strikes the flame tube wall and is entrained and reatomized by the air entering the holes and louvers.

Mr. Nerad discussed the influence of different design and operating variables on three major criterions of combustor performance: range of inflammability, combustion efficiency, and heat release rate.

Inflammability limits for the turbojet combustor were noted to cover ranges of air-fuel ratio many times wider than the ranges obtained in static inflammability tests. This combustor characteristic is attributed to the fact that the flame stabilizing zone shrinks or expands to meet the changing air-fuel ratios and thus maintains inflammability limits in the actual stabilizing zone which probably do not exceed the values from static tests. Just as in the case of static tests, inflammability limits decrease with decreasing temperature and decrease and finally vanish with decreasing pressure. This poses a problem for operation at low engine speeds and high altitudes.

Combustion efficiency is usually above 90 per cent, even at high altitudes when ordinary normal fuels are used at high engine speed. At low engine speeds at high altitudes combustion efficiency may become as low as 40 per cent. Also, in operating a turbojet combustor on various hydrocarbon fuels, sizeable reductions in efficiency are obtained with some of them over part or all of the operating range. By altering the technique of fuel injection, some of these fuels have burned more cleanly and more efficiently.

In present combustors, the heat release obtained per maximum cross-sectional area of the complete combustor has reached approximately one-fourth of the theoretical maximum obtainable with choking flow at the combustor outlet. A large increase in this combustion intensity would necessarily be accompanied by significantly increased losses in pressure. Based on fundamental flame speeds of hydrocarbons and a flame front thickness of 0.03 cm., it was determined that about 1 per cent of the maximum volume heat release rate is achieved in the turbojet combustor and that the chemical rate of release of energy would not be a limiting factor in turbojet combustion. The principle challenge for the future thus seems to lie in the low-pressure range.

It was concluded by the author that turbojet combustion is an extremely complex problem justifying continued refinements in old configurations as well as "prospecting" for new types.

The second paper was by Dr. Stewart Way, of the Research Laboratories of the Westinghouse Electric Company, and was entitled "Problems in the Development of Turbojet Combustion Chambers." Dr. Way described the task required of turbojet combustors and noted that the resulting problems were neither of a type that can be solved by reference to past experience with more conventional equipment nor of a type readily suitable for analytical formulation and solution by deductive reasoning. He then discussed in detail past progress and future tasks relating to five of these problems: operating range, combustion efficiency, carbon deposition, burner-wall durability, and problems peculiar to annular combustors.

The importance of burning over a wide operating range is sharply emphasized by the observation that at certain engine speeds and altitudes the combustor may fail to produce the temperature rise required for steady running of the engine and the engine will become inoperative. The particular altitudes and engine speeds that delineate the range of altitudes and engine speeds where an engine is operable from the range where it is not operable are called the "altitude operational limits." Wide operating limits and flame stability in a turbojet combustor are promoted by a calm piloting zone with reverse flow into it and by a low

value of energy release per unit cross section per unit time. The velocity of a satisfactory "reversed flow" stream was cited as about 6 per cent of the lateral jet velocity. For combustors of the type under discussion operating at standard atmospheric pressure and temperature, an upper figure of about 4,500 B.t.u. per sq.ft.sec. was cited for the energy release rate. The observations leading to these conclusions include observations of the flow patterns in a transparent combustor model both with and without burning. In the future, basic work on flame propagation and flame quenching is needed in the attempt to verify hypotheses concerning the factors affecting flame stability.

High combustion efficiency is promoted by optimum injection factors, by the use of lateral air jets to produce turbulence in the burning gases, and by avoidance of premature quenching with secondary air. A decrease in combustion efficiency and a narrowing of operating range as pressure is decreased may be due both to loss of unburned fuel because of liquid impingement on the walls, which is more pronounced at low densities, and also to narrowed inflammability limits. Future research on the combustion efficiency problem should include investigation of fuel injection features—for example, vaporizing types of fuel injector.

Carbon deposition is aggravated by the aromatic hydrocarbon constituents of fuel and by the residual and high-boiling point constituents. Carbon accumulations may result from several causes operating independently or in unison. Dr. Way described one form of deposit as a light soot that originates in the flame and accumulates wherever the airflow permits it to contact a cool surface in the combustor. Another type of deposit is a hard, horny residue that results from evaporation, cracking, and partial oxidation of liquid fuel wherever it strikes a wall that is hot but not too hot to prevent actual liquid wetting of the wall. The best overall solution to carbon deposition appears to be to sweep the wall surfaces with air films admitted through appropriately located slots.

With flame temperatures as high as 4,000° R. encountered in the combustor, durability of the wall becomes a problem. The use of metals or other materials with good resistance to high temperature is not a solution, because the high temperature gradients encountered cause distortion and cracking. The most suitable solution has been found to be to cool the liner by internal air blankets admitted through continuous slots.

Development difficulties attributed to the annular combustor are the large amounts of air and fuel for its operation, lack of symmetry around each fuel nozzle, and instability of the parallel air streams entering the combustor liner. Advantages accruing to the annular combustor are: a more compact unit, a simpler ignition problem in that interconnecting tubes are not needed, and less surface area of the liner or burner walls.

In conclusion, Dr. Way remarked that the problems that arise in the course of development of turbojet

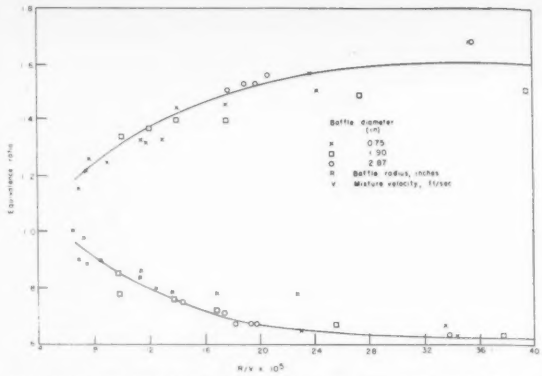


Figure 1.—Effect of mixture velocity and baffle diameter on stability range. Pressure, 1 atmosphere, inlet air temperature, 500° F.

combustors will never be completely solved because the demands made upon the engine and its component parts are always being extended.

The third paper of the session was entitled "Combustion Problems in Ram-Jet Design" by Dr. J. P. Longwell, Esso Laboratories, Standard Oil Development Company. Dr. Longwell pointed out that in the ram-jet engine combustion must be maintained in an air stream moving at velocities sometimes greater than 300 ft. per sec. as a result of the requirement of low frontal area for this high-speed engine. The problem is even more difficult because of the necessity for a minimum amount of drag in the combustor and because of the wide range of operating conditions required. Dr. Longwell proceeded to discuss the results of studies aimed at four major phases in ram-jet combustor development: choice of fuel, mixing of fuel and air, flame stabilization, and flame spreading.

Ease of handling dictates choice of a stable liquid fuel. Burning velocity and static inflammability limits are two properties that might be useful in selecting a fuel. For example, propylene oxide will burn a great deal faster than kerosene or naphtha. Also, propylene oxide can be burned at a lower pressure and over a wider range of air-fuel ratios than paraffin hydrocarbons. An experimental ram-jet type combustor burned propylene oxide more efficiently than it did pentane. Nevertheless, it is desirable to develop combustors that will burn the more plentiful, less expensive hydrocarbon fuels. With regard to fuel volatility, combustion, in general, proceeds more easily if the fuel is at least partially vaporized at the point of ignition; so it would be desirable to choose a fuel of volatility characteristics such that evaporation in the combustor is possible under the conditions of flight. The rate of evaporation is more difficult to determine and is a problem of current interest.

The distribution of the fuel at the point of ignition is exceedingly important to the combustion process. The high velocity stream of air in a ram-jet affords good atomization of the fuel; an air stream of 300 ft. per sec. relative to the fuel should produce a weight median drop diameter of approximately 40 microns. By assuming that the rate of spreading of the fuel downstream from the point of injection is proportional to

the concentration gradient, Dr. Longwell derived a mixing coefficient that describes the distribution of fuel with sufficient accuracy for many purposes.

The basis of many ram-jet combustor designs is stabilization of the flame in the wake of a baffle mounted in the flowing mixture of fuel and air. Recirculation of hot combustion products in the wake of the baffle is believed to serve as the continuous source of ignition. Fig. 1 shows the results of a study made with various baffles of circular cross section mounted centrally in and near the exit of a 6-in. duct through which a homogeneous combustible mixture flowed. Combustion was supported on the baffle. It is noted that, for values of baffle radius (R) divided by the mixture velocity past the baffles (V) above 20×10^{-5} sec., little gain is to be expected by using larger flameholders for a given mixture velocity. If R/V is considered as a function of blockage ratio in the duct, it is obvious that at large values of blockage, the velocity past the baffle (V) will increase and the value of R/V will diminish. The highest R/V is thus obtained at a blockage ratio of 0.3.

Because the flame spreads through the unburned mixture from the surface of the flame held in the wake of the flame stabilizers, one would expect that to obtain a short combustor many flame stabilizers would be required and that to keep the blockage caused by the stabilizers low they would have to be small. But it has been pointed out that small stabilizers reduce the stability range. A compromise is thus necessary, and more accurate data on baffle stability and on combustion rate are needed.

Dr. Longwell's paper indicates that generalization of many of the processes involved in ram-jet combustion is possible and that a large amount of further research is needed in view of the variety of sizes of ram-jet and of conditions under which ram-jets will operate.

Dr. Glenn C. Williams, Department of Chemical Engineering, Massachusetts Institute of Technology, presented the fourth paper entitled "Basic Studies on Flame Stabilization." Dr. Williams reported research intended to determine the mechanism of anchoring flame in high-velocity streams of combustible gas. The specific object of the research was to examine independently the effect on flame stabilization on bluff shapes of air-fuel ratio, approach gas velocity, turbulence in the approach gas stream, flame stabilizer size and shape, and fuel type.

The experimental apparatus consisted of a constant cross section, 3- by 1-in., low-turbulence duct, 17 in. long, through which homogeneous mixtures of gaseous fuel in air could be flowed steadily with entrance pressure and temperature of about one atmosphere and 300°K. and at entrance velocities from 20 to 350 ft. per sec. The rectangular combustion chamber had opposing walls of heat-resistant glass to allow observation of the flame. Flame stabilizers of simple shape and of various sizes were supported with axes normal to the direction of flow between the glass walls.

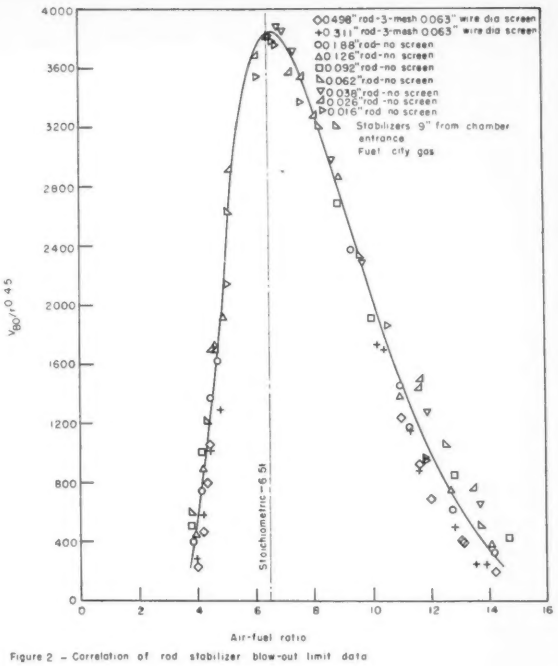


Figure 2 – Correlation of rod stabilizer blow-out limit data

The limiting gas velocity above which flames blew off the stabilizers was determined as a function of air-fuel ratio for nine rods varying thirty-fold in diameter, both with and without a turbulence-promoting screen at the chamber entrance. Examination of high-speed movies of blowouts showed that flame stabilization requires a recirculation of hot combustion products behind the stabilizer, thus providing a continuous source of ignition. A theoretical consideration of this mechanism on the basis of a thermal ignition concept shows that the blowout velocity (V_{BO}) for a bluff object should be proportional to the product of the stabilizer thickness (r) to a power and some function of air-fuel ratio. The experimental data correlated in Fig. 2 verify this; the exponent for the stabilizer thickness was found to be 0.45. This relationship was further experimentally demonstrated to hold for a closed-edge gutter, for different open-edge gutters, for a flat plate, for various rods with fairing on the upstream face, and for multiple rods in a plane, as well as for the simple rods described, as long as the ratio of the span to the thickness of the stabilizers was greater than two. For ratios of span to thickness of less than two, the corresponding blowout velocity was proportional to the first power of the thickness, as also observed by Dr. Longwell.

Increasing the turbulence in the approach gas stream decreased the range of approach velocity and air-fuel ratio over which flame was maintained. Heating the flame stabilizer widened the stability limits; cooling it narrowed them.

With the two fuels (propane and city gas, a methane-hydrogen mixture), the effect on stability limits was in the direction of the accompanying change in laminar flame speed. However, for propane-air mixtures maximum blowout velocities occurred with fuel-rich

mixtures, and for city gas maximum velocities occurred with fuel-lean mixtures. The tentative conclusion reached from this is that molecular diffusion into the eddy region changes the air-fuel ratio in the eddy zone from that in the main stream. Otherwise, the observations of the characteristics of flame stabilization on bluff shapes can apparently be explained on the basis of a thermal ignition theory and the gross aerodynamics of the system.

Jet Engine Thrust Augmentation and Controls

By

Eugene J. Manganiello

The Evening Session was devoted to a discussion of thrust augmentation and control of turbojet engines. Before introducing the speakers, the Chairman of the Session, Benjamin Pinkel, Chief of the Fuels and Thermodynamics Division, Lewis Flight Propulsion Laboratory, N.A.C.A., explained that it had become customary for the N.A.C.A. to present a program on some aspects of a general aircraft propulsion problem and that the evening's program consisted of three theoretical papers on various phases of the augmentation problem prepared by members of the staff of the Lewis Flight Propulsion Laboratory. One paper discussed the principles of the various augmentation methods and the effect of design parameters on performance. The second paper presented a general discussion of the control problems associated with the tailpipe burning method of augmentation, and the third paper compared the performance of the various augmentation systems.

The first talk entitled "Analysis of Turbojet Thrust Agumentation Cycles" was delivered by Bruce T. Lundin, Head of the Jet Propulsion Research Section, Lewis Flight Propulsion Laboratory. Three augmentation methods were considered—tailpipe burning, water injection, and air bleed-off—and results of analytical studies of these methods were presented in order to provide an understanding of their basic operating principles and to summarize their performance characteristics as affected by design and operating variables.

The tailpipe burning method of augmentation was first described. It consists of introducing and burning fuel between the turbine and exhaust nozzle of the engine with resulting increase in temperature of exhaust gases and, hence, increased jet velocity and thrust. The effect of design variables on performance of tailpipe burning was illustrated by plots of the ratio of augmented thrust to normal thrust for an engine having component efficiencies and operating conditions representative of present-day engines. This augmented thrust ratio increases with increase in burner exit temperature and decreases with increase in burner inlet velocity. For sea-level altitude and zero flight Mach Number, a burner exit temperature of 3,800°R. results in an augmented thrust of 1.48 times the normal engine thrust at a burner inlet velocity of 400 ft. per sec. At the same temperature and at a burner inlet velocity of 700 ft. per sec., the augmented thrust ratio is 1.2.

Low burner internal drag coefficient is advantageous for maximum thrust; however, some drag is necessary for satisfactory combustion, particularly for altitude operation. This situation constitutes another argument for low burner inlet velocity which minimizes the unfavorable effects of high burner drag. In addition, low burner inlet velocity is desirable "per se" for satisfactory combustion efficiency and stability. The use of a low burner inlet velocity does, of course, require a larger tailpipe burner diameter, which may be limited by airplane installation considerations.

Both augmented and normal thrust decrease progressively with increased turbine discharge velocity and decreased diffuser efficiency, indicating the desirability of designing the turbojet engine with a low turbine discharge velocity in order to realize high thrust augmentation and to minimize penalties during nonburning or cruise operation. Alternatively, if the engine has a high turbine-discharge velocity, every effort should be made to obtain a high diffuser efficiency.

The ratio of augmented to normal thrust increases considerably with increase in Mach Number; for example, at sea-level altitude the augmented thrust ratio increases from about 1.5 at Mach Number zero, to about 2 at Mach Number 1, and to about 4 at Mach Number 2. Altitude does not appreciably affect the augmentation up to Mach Numbers of about 1.0. At higher Mach Numbers, the augmented to normal thrust ratio decreases with increase in altitude and at Mach Number 2 is about 30 per cent lower than the corresponding sea-level value.

Mr. Lundin next discussed the water injection method of thrust augmentation and considered both compressor inlet and combustion chamber injection. Injection of a volatile liquid such as water into the compressor inlet results in cooling of the air prior to compression and during the compression process with resultant increase in compressor pressure ratio and

N.A.C.A. Speakers comprising Evening Session Panel *(left to right)*: Benjamin Pinkel, Chairman; Bruce Lundin; Melvin S. Feder; Richard Hood; and Eldon W. Hall; all of Lewis Flight Propulsion Laboratory, N.A.C.A.

mass flow. These increases, of course, result in increase in jet velocity and thrust of the engine.

Calculation of the effect of compressor inlet injection on the performance of a typical present-day turbojet engine were made using a special psychrometric chart and Mollier diagram developed specifically for such application. At sea-level altitude and zero Mach Number, injection of sufficient water to saturate the air at compressor discharge (water-air ratio of 0.05) indicated an increase in the compressor pressure ratio from the normal value of 4 up to 4.9 and an increase in the air flow of 15 per cent. The corresponding augmented thrust ratio was 1.4. Increase in ambient air temperature reduces the absolute thrust level of the engine but permits injection of a greater quantity of waver before reaching saturation conditions with attendant increase in the ratio of augmented to normal thrust.

Increase in flight Mach Number results in large increases in the augmented thrust ratio and the necessary water-air ratio; for example, at sea-level altitude and Mach Number 2, the calculated augmented thrust ratio for compressor discharge saturation was 3.35, and the water air ratio was 0.12. Increase in altitude results in reduction of the augmented thrust ratio for a given water-air ratio as limited by saturation.

Injection of water into the combustion chamber was explained as causing a shift in the equilibrium running point of the engine to one of lower compressor airflow, higher compressor pressure ratio, and higher total mass flow (i.e., air plus injected water). The engine thrust is accordingly increased by virtue of the higher mass flow and the higher jet velocity provided by the increased pressure ratio. In addition to these effects, the increased gas constant and specific heat of the water-air mixtures also contribute to a smaller degree to an increase in the turbine-discharge pressure and, hence, in the jet velocity. The augmented to normal thrust ratio provided by combustion chamber injection was shown to be about the same as that provided by compressor inlet injection, but the required water injection rates are about twice as great as for compressor inlet injection.

The third thrust augmentation method considered, the air bleed-off cycle, was described as consisting of the bleeding off of air from the compressor discharge, burning it with fuel to high temperatures in an auxiliary combustion chamber, and discharging it through a nozzle at high velocity. The air that is removed from the primary engine is replaced with water, which vaporizes in the engine combustion chamber and passes through the turbine as steam. Injection of water into the compressor inlet is also incorporated in the bleed-off method to take advantage of the additional thrust augmentation possible by this method.

The complicated interrelationships among the many variables involved were illustrated by a sequence of curves, which showed the effect of bleed-off flow on combustion chamber water injection flow, primary engine exhaust nozzle area, and primary and auxiliary engine thrust and liquid flows. The resultant effects of the variables were summarized by a plot of the total augmented to normal thrust ratio against the total liquid flow. For the case of fixed area for the primary engine exhaust nozzle, a total liquid flow of about 18 times the normal fuel flow results in stoichiometric fuel-air ratio in the primary engine. At this maximum condition the augmented thrust is 1.8 times the normal engine thrust. If the exhaust nozzle is permitted to vary, the maximum total liquid flow may be increased to about 30 times the normal fuel flow with an attendant increase in augmented thrust ratio to about 2.25.

Mr. Lundin ended his talk with a recapitulation of the principal results of the analyses and with the qualification that experimental attainment of the theoretical values of maximum augmented thrust may be limited by considerations not accounted for in the analyses. For example, injection of large quantities of liquid may interfere with the combustion process in the engine combustors.

The second paper entitled "Automatic Control Considerations for Turbojet Engine with Tailpipe Burning" was presented by Melvin S. Feder, coauthored with Richard Hood, both of the Accessories and Controls Section, Lewis Flight Propulsion Laboratory.

The use of any of the thrust augmentation methods adds problems and complications to the engine automatic control system. Mr. Feder selected the tailpipe burning method of augmentation to illustrate in a qualitative manner the general problems and the factors that must be considered in the satisfactory solution of the control problem for augmented turbojet engines. Because the full potentialities of tailpipe burning are realized only when the engine is operated at its maximum speed and turbine temperature, the problem of the control system is to provide critical control of those variables with a minimum of overshoot during transient operation.

The interrelation of the engine operating variables was described with the aid of a block diagram of an engine and tailpipe burning. The independent variables—engine fuel flow, tailpipe fuel flow, and exhaust nozzle area—that can be adjusted to control operation are considered as input quantities to the engine and tailpipe burner blocks. Turbine outlet temperature and airflow are quantities that feed from the engine into the tailpipe, while turbine back pressure feeds back from the tailpipe to the engine. Torque is considered an engine output parameter that feeds back through the engine internal feedback loop that converts torque to speed. Considering first the turbojet engine with fixed exhaust nozzle area and no tailpipe burning, a change in engine fuel flow affects turbine outlet temperature, airflow, and torque. Changes in temperature and airflow, in turn, affect turbine back pressure. Torque affects engine speed, which further affects airflow, turbine outlet temperature, and torque. Thus, each input to the system affects all the outputs. In a similar manner, changes in tailpipe fuel flow or exhaust nozzle area affect the different variables. In short, the variables are all interrelated, so that a change in engine conditions is reflected

eft to right):
S. Feder;
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to the tailpipe and, in turn, this change in tailpipe conditions is reflected back to the engine.

The principle of a closed loop control system was next illustrated by a block diagram. A measurement of the actual engine speed is fed into a differential that compares the measured speed with a desired speed. The difference, or error, is fed into a controller that acts on engine fuel flow in such a manner as to reduce the speed error. A similar control for maintaining required turbine outlet temperature was illustrated, wherein the difference between measured and desired temperature is fed into a controller that acts on the exhaust nozzle area, increasing or decreasing it depending on whether temperature should be decreased or increased, respectively.

Combination of two such controls provides a possible system for controlling an engine with tailpipe burner. This control system is shown only to illustrate the control problems for an engine with tailpipe burning. For this case, tailpipe burner fuel flow is independently varied to obtain thrust changes. The change in tailpipe burner fuel flow causes a change in turbine back pressure, turbine outlet temperature, torque, and, therefore, engine speed. The temperature control senses the change, or error, in turbine outlet temperature and adjusts exhaust nozzle area to eliminate the error. At the same time, however, the speed control senses an error in engine speed and changes engine fuel flow to reduce the error. Because of the interrelation of the engine variables, a change in engine fuel flow will affect turbine outlet temperature and the temperature control will therefore be affected by the action of the speed control. Thus, because of the interaction of the engine variables, each control has an effect upon the other.

If the response of the temperature control was such that the error in temperature approached zero during a transient—that is, sensing the error and action to correct the error is instantaneous—interaction between the engine and tailpipe controls would be eliminated. In practice, however, such response is impossible because of friction and inertia in the exhaust nozzle, power limitations, thermocouple time lag, etc. In the illustrative case considered, the control problem then becomes one of designing into the system relations between speed error and fuel flow, temperature error, and exhaust nozzle area that are consistent with practical limitations and still prevent excessive engine speeds and temperatures during transient operation.

To accomplish this result, the designer must first have data on the transient characteristics of the engine for which the control system is to be designed. Such data, which can be obtained experimentally and analytically, were illustrated by plots of typical transient relations. Curves of the instantaneous variation of engine torque and turbine outlet temperature with turbine back pressure at constant engine speed and fuel flow and the variation of turbine outlet temperature with fuel flow at constant speed for several values of back pressure were included to give an indication of the magnitude of the interacting effects. Several sets of such curves are required by the designer, because they represent instantaneous relations and, as soon as a change in one variable occurs, the different curves will all change. It would thus be virtually impossible to examine all the required curves at one time and perceive exactly what happens when one variable is changed. The curves can, however, be used to describe the engine's transient characteristics in terms of a differential equation that can then be used to determine quantitatively just what functions should be built into the control. The final design of a control system by this method is, unfortunately, difficult and tedious because the method involves trial and error and the solution of high order differential equations.

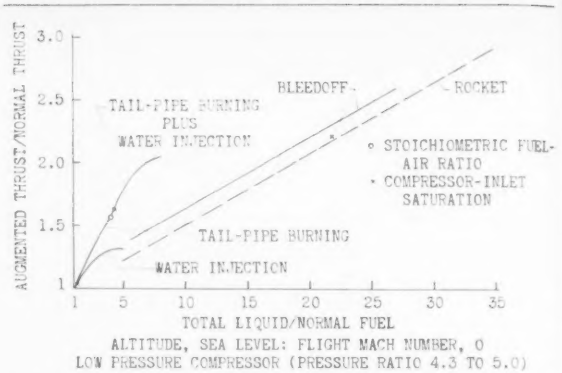

FIG. 3. Variation of ratio of augmented to normal thrust with ratio of total liquid to normal fuel.

The difficulties involved in this method may be overcome by the use of an electronic simulator that duplicates the transient characteristics of the engine control. The engine simulating components are adjusted to duplicate transient characteristics of the engine. The control elements are then imposed on the system and the resultant characteristics observed. The control elements can be systematically varied until the desired response characteristics are obtained.

The final paper of the evening entitled "Comparison of Various Methods of Thrust Augmentation" was presented by Eldon W. Hall, Head of the Propulsion Systems Analysis Section, Lewis Flight Propulsion Laboratory. In addition to the tailpipe burning, water injection at the compressor inlet, and bleed-off methods discussed by the first speaker, Mr. Hall considered rocket assist and a combination of tailpipe burning and water injection. Comparison of the augmentation methods was made for altitudes of sea level and 35,000 ft. and for flight Mach Numbers of 0, 0.85, 1.50, and 2.50. Two engines were considered, one having a compressor pressure ratio at sea-level static conditions of 4 (low-pressure compressor) and the other a pressure ratio of 11 (high-pressure compressor), which could correspond to one- and two-stage centrifugal compressors, respectively. The component efficiencies and operating conditions were typical of average present-day turbojet engines. The rockets were assigned a specific impulse value of 190 lbs. per lb. per sec.

The performance of the different systems was first compared on the basis of the ratio of augmented to normal thrust as a function of the ratio of total liquid to normal fuel flow. Such a comparison plot is shown in Fig. 3 for the engine with the low-pressure ratio compressor at sea-level altitude and zero Mach Number. The most economical augmentation method is tailpipe burning, which provides a maximum thrust ratio of 1.55 at a liquid ratio of 4.0 as compared to 1.32 with water injection at the same liquid ratio. The circle on the tailpipe burning curve represents a stoichiometric fuel-air ratio and is the maximum that can be obtained with tailpipe burning. Large increases in thrust can, however, be obtained by adding water-injection to the tailpipe burning method when the overall fuel-air ratio is stoichiometric. A thrust ratio of 2.05 at a liquid ratio of 8.0 can be obtained by this method when saturating the air at the compressor outlet. The cross on this and the other curves represents the condition for which just sufficient water is injected to saturate the air at the compressor inlet.

Bleed-off is less efficient than tailpipe burning or the combination of tailpipe burning and water injection, inasmuch as a higher liquid ratio is required for the same thrust ratio. A higher maximum thrust ratio is possible, however, with bleed-off. For example, a maximum thrust ratio of 2.60 can be obtained with bleed-off at a liquid ratio of about 26, at which condition the fuel-air ratio in the primary combustion chamber is stoichiometric. The rocket assist method is the least efficient inasmuch as it requires the highest liquid ratio for a given thrust ratio. It is, however, approximately competitive with the bleed-off system and, furthermore, has no theroetical limit on maximum thrust ratio.

Similar sets of curves were presented for other flight conditions and showed similar relative trends but different values of the thrust ratio. In order to illustrate more effectively the effects of flight conditions, the maximum thrust ratio of each method was plotted directly against flight Mach Number and altitude, respectively. All methods show an increase in the maximum thrust ratio as the flight Mach Number is increased, with a corresponding increase in the liquid ratios. For example, increasing the flight Mach Number from 0.85 to 2.50 increases the thrust ratio with the combination of tailpipe burning plus water injection from 2.34 to 9.3 and with bleed-off from 2.88 to 10.4. All methods show a moderate decrease in maximum thrust ratio as altitude is increased to 35,000 ft., above which the augmentation remains about constant. Tailpipe burning is affected to a smaller extent by altitude than any of the other methods, the maximum thrust ratio decreasing from 2.12 to 1.92 as altitude is increased from sea level to 35,000 ft. at a flight Mach Number of 0.85.

The engine with the high compressor pressure ratio yields about the same value of the augmented to normal thrust ratio as the low pressure ratio engine for a given liquid ratio. Higher maximum values of the thrust ratio are, however, possible with the high pressure ratio engine but at higher values of the liquid ratio. The greatest increase in maximum thrust ratio is obtained with the methods involving water injection. For example, at sea-level altitude and 0.85 flight Mach Number, for a change from the low to the high pressure ratio compressor the maximum thrust ratio with the combination of tailpipe burning plus water injection increases from 2.90 to 4.36, whereas with tailpipe burning alone the maximum thrust ratio increases from 2.12 to 2.26.

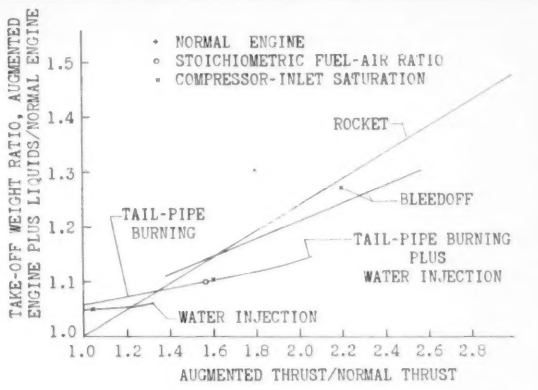

FIG. 4. Variation of take-off weight with ratio of augmented to normal thrust.

The speaker next considered the effect of the weight of the added equipment required by each method in a comparison of the augmentation systems for the take-off condition. The sum of the engine weight, the added equipment weight, and the fuel or liquid weight required for 6 sec. of operation divided by the normal engine weight was plotted against the augmented to normal thrust ratio (see Fig. 4). The fuel and liquid requirement for 6 sec. of operation is included to account for the climb to clear a 50-ft. obstacle after the airplane becomes air-borne. The principle of this basis of comparison is that the gross weight of the airplanes utilizing the different methods of augmentation is the same at the instant of take-off and that differences in required weight of liquid for the ground run can be incorporated as changes in airplane initial gross weight without affecting the airplane's flight preformance.

The curves show that for small amounts of augmentation, below about a 1.2 thrust ratio, the rocket method entails the least additional weight. For higher values of augmentation the methods in order of increasing weight of additional equipment are: water injection, tailpipe burning, combination of tailpipe burning plus water injection, bleed-off, and rocket assist. The best augmentation method for take-off depends on the maximum value of augmentation required. For example, if the required thrust ratio is 2.0, the best method is the combination of tailpipe burning and water injection, for which the weight of engine, equipment, and liquids is 14 per cent greater than the weight of the normal engine.

Final comparison of the augmentation methods was made on the basis of airplane load-range characteristics,

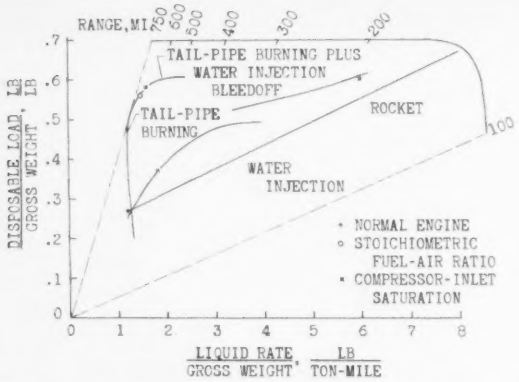

Fig. 5. Load-range characteristics of airplane powered by turbojet engines with various methods of thrust augmentation. Altitude, 35,000 ft.; flight Mach Number, 1.50.

wherein the engine was assumed to be operating in the augmented condition for the entire time of flight. The details and assumptions of the analysis are similar to those of the Symposium on the Performance of Various Types of Propulsion Systems presented in 1947 by members of the staff of the N.A.C.A. Cleveland laboratory at the I.A.S. Second Annual Aircraft Propulsion Meeting.

It may be recalled that airplane load-range characteristics were generalized in the Symposium by plots of disposable load per unit gross weight against fuel rate per mile per unit gross weight. Similar plots were used in the present paper to compare the augmentation systems at an altitude of 35,000 ft. and a flight Mach Number of 1.5. One of these is reproduced in Fig. 5. Maximum range is obtained when all of the disposable load is fuel or liquid. For this condition, dividing the ordinate (total pounds of liquid) by the abscissae (pounds of liquid per mile) gives the maximum range in miles. Hence, the slope of a line from the origin through any operating point represents the maximum range for that point. Direction lines and a scale are included in the figure for convenience in reading range values.

Operation with the normal engine is indicated by the plus in the lower left portion of the plot, and operation with increasing amounts of augmentation for each method is represented by ascending points on the different curves. The curves indicate a maximum range of 415 miles for the normal engine for the flight conditions and assumptions of the analysis. As augmentation by tailpipe burning is increased, disposable load is increased without much change in liquid rate per mile, resulting in increased range. Maximum range (750 miles) occurs at somewhat less than stoichiometric fuel-air ratio. Adding water injection to tailpipe burning increases the disposable load but, because of the increase in liquid rate, results in slightly shorter maximum range than with tailpipe burning alone. Increasing augmentation by water injection alone increases the disposable load relative to the normal engine but also increases the injection rate so that range is not increased. Increase in augmentation by either bleed-off or rocket assist also increases disposable load but at the expense of considerable increase in liquid rate with resultant decrease in range. Thus, at a flight Mach Number of 1.5, tailpipe burning is the only augmentation method that, when used for the entire flight, will increase the range over that for a normal engine.

In conclusion, Mr. Hall explained that, for ranges less than maximum, tailpipe burning (and the other methods to a lesser extent) provides considerable improvement in pay-load capacity and that at higher flight speeds the addition of tailpipe burning to the turbojet engine provides even greater improvement in maximum range and pay-load capacity.

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Designing for Gas-Turbine Materials*

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Wright Aeronautical Corporation

IT SEEMS APPROPRIATE to pause at this stage in the partnership of metallurgy and gas-turbine powerplant design and examine the relationship in the light of experience. The metallurgist must have a good understanding of fundamental engine requirements, and he must impress the designer with the importance of critical operating temperatures, stresses, and fabrication as they affect reliable engine operation and life. Materials and their processing, particularly low-alloy steels, have been brought to a high level of standardization and uniformity, but the introduction of high-temperature materials has changed the situation. Until the manner in which variables in melting and processing affect physical and mechanical properties is better understood, the operating requirements of a high-temperature alloy must be restricted to conform to its known capacity and its usefulness must be broadened as development permits.

Turboprop and turbojet engines have many requirements in common with aircraft piston engines. Although there are obvious similarities in the problems of low-alloy steel parts, such as shafts, gears, studs, nuts, and bolts, our preoccupation with fatigue failures has not abated in the least with the advent of the new engines. Resonant vibration may cause fatigue failures more difficult to track down and eliminate than those common to piston engines.

Our chief concern is with the unique metallurgical and design problems of gas-turbine engines and particularly with combustion and expansion sections.

Engine parts have been strengthened only when experimental testing has required the avoidance of unnecessary weight. Such testing is always extremely severe in order to shorten development time and to provide a safety factor under normal conditions. This severe testing of aircraft gas turbines should be done with reservations based on the fundamentals of high-temperature metallurgy. When operating temperatures pass about 1,000° F., we must also pay *equal* attention to exact temperature and to time at temperature, as well as to stress, and investigate these variables painstakingly.

Fig. 1 shows that, on the basis of the stress to produce rupture in 1,000 hours at the temperatures given, two forgeable alloys (S-816 and Inconel X) and two cast alloys (Stellites 21 and 31) are the best. Of the four, Inconel X is decidedly superior in strength at temperatures up to about 1,450° F., but, above this temperature, it loses strength more rapidly than the other three materials and becomes the worst just under 1,550° F. This is true even for times much under 1,000 hours, although cross-over temperatures may shift upward for shorter times. S-816 is much more stable than Inconel X at 1,500° F.; although Inconel X is initially stronger than S-816, it falls lower than S-816 after a time of less than 1,000 hours.

The operating life of such parts as turbine blades must be decided in advance, or we shall employ a material whose lack of stability at the operating temperature makes it superior for only *part* of its expected operating life.

Obviously, such factors as oxidation and corrosion resistance enter into the general problem. Tungsten and molybdenum might be valuable materials, as such, if they did not burn up rapidly in oxidizing atmospheres at relatively low temperatures.

It is easy for the designer to forget that at temperatures over 1,000° F. the residual tension in a bolt or capscrew—and, hence, the clamping stress—will usually drop appreciably as a result of creep. Curves are available which show this effect for a common high-temperature bolting material, hot-rolled and stress-relieved 19-DL, as a function of temperature and time, with a room-temperature prestress of 50,000 lbs. per sq.in. The differential expansion of dissimilar materials bolted together may introduce excessive stresses, with consequent loosening or rupture of the bolt.

To the loads imposed on a turbine disc by centrifugal action must be added those caused by the thermal gradient from rim to hub. It is desirable to use a disc material of low coefficient of expansion, a characteristic not readily obtainable. If the turbine blades are attached by welding, steep thermal gradients from rim to hub may cause repeated plastic compression of the rim, with resultant residual tension when the disc is cool, and progression of interblade cracks through the weld and into the disc. The advantages of the coolest possible turbine disc or the least possible thermal gradient in the turbine disc are obvious from the potential improvement in durability and the lesser weight.

Thermal stresses may be critical in turbine rotor and stator blades, combustion-chamber liners, and sheet-metal shrouding components. When a hot area wholly or partially surrounded by cooler metal cools, residual tension is produced which may cause cracking, particularly when the cycle is repeated many times.

* Condensation of a paper presented at the Flight Propulsion Session, Seventeenth Annual Meeting, I.A.S., New York, January 24–27, 1949. Copies of the complete paper, *Preprint No. 184* (reproduced from typewritten copy, 15 pages, including 7 figures) may be obtained from the I.A.S. Preprint Department. See pages 53 and 78 in this issue for price and details of other I.A.S. publications.

† Chief, Materials Laboratory.

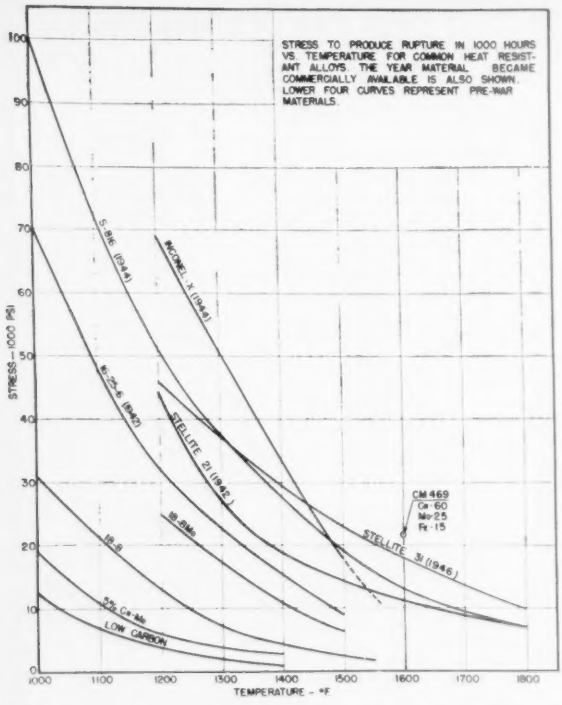

FIG. 1. Stress to produce rupture in 1,000 hours vs. temperature for nine heat-resistant alloys.

The hot area of parts of thin section will usually bulge plastically to relieve the compression and will become permanently deformed. In turbine stator blades subjected to cyclic thermal stress in a test rig, the thermal gradient is extreme at the thin trailing edge, midway between the inner and outer blade shrouds. They can crack with no restraint at the blade ends. The only cure is a lessened peak temperature or thermal gradient if the material selected has a high short-time (less than 1 hour under stress to rupture) tensile strength, high thermal conductivity, and low coefficient of expansion. Little can be done other than to choose an alloy with the best short-time strength at the peak operating temperature. It is more effective to reduce thermal stresses by insulating the blade with a ceramic or to increase the blade cross section to reduce the thermal gradient. Gas temperature must be uniform over the blade. Thermal stress may often be more important than mechanical stress, even for rotating turbine blades.

A thermal fatigue machine has been developed in which the blades or otherwise thin-edged specimens are mounted on a traveling carriage that holds the specimen over a hot flame for 1 min. and then moves it over a cool air jet for 1 min. Thermocouple data are recorded continuously.

The designer of sheet-metal parts must consider thermal differentials as a primary cause of stress and sheet-metal edges as sources of stress concentration. Per cent elongation at failures vs. sheet-metal thickness for S-590, a well-known heat-resistant alloy, has been charted. The apparent trend toward a decrease in ductility with decreasing sheet thickness becomes even more marked if cut edges are not carefully deburred and is most marked for materials of lower nominal ductility or high notch sensitivity. It is not advisable to have discontinuities in sheet-metal parts where hot spots may occur near an edge and cause high stresses in areas least able to adjust to such conditions. If the trailing edges of turbine blades were reduced to the ideal aerodynamic thickness, they would probably be too thin for durability.

The preceding cases imply the great importance of having temperature, stress, and time factors well determined for parts operating at elevated temperatures. Instrumentation for obtaining such information should merit even more investment in time and money than it has for piston engines.

Certain lower-strength materials have been included in Fig. 1 for comparative purposes. With the exception of Timken 16-25-6 alloy, all lower-alloy, lower-strength materials are of pre-World War II vintage. However, even the latest commercial high-temperature casting alloy, Stellite 31, was available in 1944, having been developed through modification of Vitallium (Stellite 2) originated for medical usage prior to 1941. From the development dates for each of the four top alloys, we should not expect to maintain the past development rate. The postwar years have been marked by large-scale coordinated efforts in high-temperature metallurgical research, but there have been no startling developments. A chromium-base alloy, CM469, has shown some improvement, as indicated by a 1,600° F., 1,000-hour rupture point on Fig. 1, but it is brittle at room temperature and not yet castable commercially.

The brittleness and low resistance to thermal shock of solid ceramic blades have prevented their extended use in practice. Metal-bonded ceramics may be a more immediate answer. Generally, the only safe prediction for the future is that we must certainly know more about the materials already in use.

Nickel, cobalt, tungsten, columbium, and other materials are virtually nonexistent in the United States. In our zeal to produce the best in power and range and to beat our competitors, we may be inclined to brush this fact aside. Some parts, such as rotors, can be made to operate cooler than was first anticipated. Many parts, such as tail cones or even liners, can likely be fabricated of low-carbon steels coated with ceramic. Design ingenuity on hollow blades and cooling ducts can lower temperatures and permit use of materials that will save strategic elements.

With proper consideration for the limitations of our present alloys and with an improving background for understanding these limitations, we should be able to effect substantial improvement in the performance of turboengines without resorting to wishful thinking about a Utopian material that would permit unlimited power and efficiency with a minimum of drafting-room labor.

Preliminary Development of a *Jet-Propelled Helicopter*

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Marquardt Aircraft Company

ABSTRACT

Results of a theoretical analysis are presented comparing the load-carrying capacity of ram-jet, pulse-jet, and compressor-burner jet helicopters with conventional machines. It is shown that the ram-jet helicopter is not competitive, whereas a selection between other propulsion systems is dependent upon the flight endurance, pulse-jet and compressor-jet helicopters having about the same performance and being superior in load-carrying capacity to a conventional machine for endurances up to the order of 3 hours as based upon present jet engine performance.

Results of early experimental investigations of compressor-burner jet helicopters are presented. Tests substantiated theoretical calculations, but lack of a suitable gas-turbine-driven compressor halted the project. Results of early ram-jet and pulse-jet bench and whirl tests are presented which resulted in the abandonment of the ram-jet engine because of success in whirling the more efficient pulse-jet engine. The Marquardt M-14 pulse-jet helicopter is described, along with a description of preliminary flight tests of this machine and a discussion of existing problems.

Presented at the Rotating Wing Aircraft Session Seventeenth Annual Meeting, I.A.S., New York, January 24–27, 1949.

*President.

INTRODUCTION

IN 1943 THE MARQUARDT AIRCRAFT GROUP, with valuable advice from Dr. Theodore von Kármán, began design studies of jet-propelled helicopters. The jet helicopter under consideration at that time was to be driven by ram-jet engines and in all other respects was similar to the M-14 helicopter described below and shown in flight in Fig. 1. It became immediately apparent from studies of this machine that it would be necessary to expend considerable time and money on the development of the ram-jet engine. Accordingly, proposals were submitted to the Bureau of Aeronautics, U.S. Navy, in 1944 covering both the development of the ram-jet engine and the development of the ram-jet-powered helicopter. In 1945 these proposals resulted in a contract for the development of a 20-in. diameter subsonic ram-jet engine. This development was undertaken by the Marquardt Aircraft group, working at the University of Southern California. The development of this and succeeding ram-jet engines undertaken by

the Company itself grew to be such an interesting and time-consuming task that we never really actively returned to the primary objective of developing a jet helicopter. Nevertheless, a considerable amount of work has been accomplished on the subject on a part-time basis. The purpose of this paper is to describe these jet helicopter developments starting from the first analytical studies; progressing through the construction and test of a compressor-burner jet helicopter rotor and whirl tests of ram-jet and pulse-jet engines; and, finally, the construction and flight testing of the M-14 pulse-jet helicopter.

(I) Analytical Studies

We were convinced in 1943 that the three intrinsic advantages of jet-propelled helicopters would give them an important place in the rotary-wing field. First and second: The lack of torque reaction and the elimination of the transmission and clutch would make possible an extremely simple, inexpensive machine. Third: The inherent light weight of the jet propulsion system, in combination with the weightsavings gained above, would result in a machine that could carry large pay loads for short endurances, endurances that we felt represented the most significant regime for helicopter operation. In 1944 we received a small N.A.C.A. contract at the University which permitted us to check the above arm-chair reasoning with a fairly complete analytical study of the performance possibilities of the jet-propelled helicopter. The numerical results computed at that time are no longer of great interest, since the calculations were made before any real data on the jet system components were available. However, the general conclusions are about the same as obtained in later studies, which shall be considered here.

Performance characteristics are compared for four helicopters: ram-jet, pulse-jet, compressor-burner jet, and conventional gear drive. The ram-jet and pulse-jet helicopters are typified by the M-14 helicopter shown in Fig. 2. The basic differences between the helicopters required to carry these two power plants lie in the design rotor tip speed and the means of starting the rotor. In the case of the ram-jet machine, the tip speed is high, and it is necessary to bring the rotor up to speed with some auxiliary power supply. In the case of the pulse-jet drive, it is necessary to start the pulse-jet by some means, probably using a compressed air supply, and then allow the pulse-jet engine to bring the rotor up to speed.

A schematic sketch of a compressor-burner jet helicopter is shown in Fig. 3. Compressed air is supplied by an engine-driven compressor in the fuselage. This compressed air is carried out through the blades to burners and exhaust nozzles at the blade tips.

The compressor-burner type jet helicopter actually includes a whole family of machines, since the basic parameters are varied. At one extreme, we have a machine with a large compressor normally operating at a low compression ratio accompanied by little or no burning at the blade tip. In the middle range, we have the most promising machine in this class which incorporates a medium-sized compressor normally operating at a fairly high compression ratio with high temperature combustion at the blade tip. On the other extreme, it is possible to visualize a machine having no compressor and deriving its power completely from combustion at the blade tips. In the case of an air inlet at the blade root, this becomes an example of the so-called Nerst turbine; with an air inlet at the blade tip, it becomes a simple ram-jet power plant.

Our detailed analysis of the ram-jet and compressor-burner jet helicopter, as compared with the conventional gear drive, is currently being presented in reference 1. Accordingly, we will present here only a summary of those results as compared with the pulse-jet-driven helicopter. These performance data are shown in Fig. 4. It may be seen that, according to these calculations, the ram-jet helicopter carries more pay load than the conventional gear-driven machine up to $\cong 1^1/_2$ hours duration. The compressor-burner jet helicopter carries a little less pay load than the ram-jet machine up to $\cong {}^1/_2$ hour but carries more pay load than either the ram-jet or a conventional gear drive from $\cong {}^1/_2$ to $\cong 2^1/_2$ hours. It may be seen that the pulse-jet-driven machine carries as much pay load as the ram-jet at short endurances and equals the performance of the compressor-burner jet up to the duration where neither offers an advantage over the conventional gear drive. For 1 hour the pulse-jet helicopter carries 90 per cent more pay load than the conventional machine; for 2 hours it carries 50 per cent more pay load. From this

Fig. 2. Sketch of M-14 helicopter.

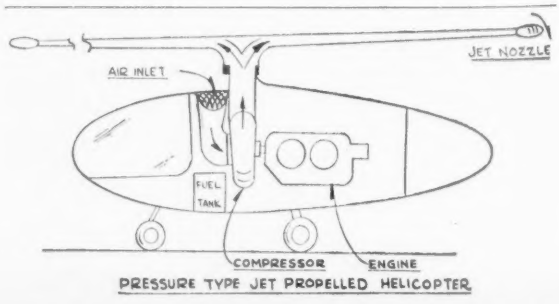

Fig. 3. Schematic drawing of compressor-burner helicopter.

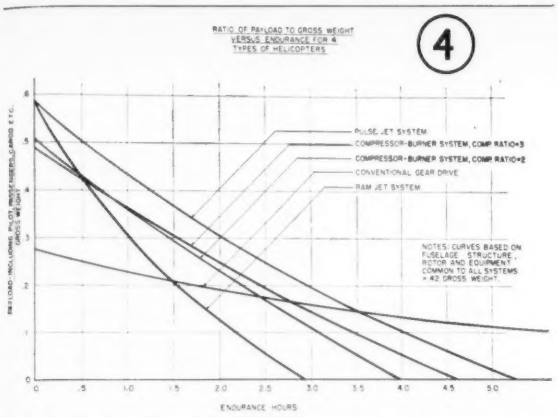
RATIO OF PAYLOAD TO GROSS WEIGHT VERSUS ENDURANCE FOR 4 TYPES OF HELICOPTERS
4
PULSE JET SYSTEM
COMPRESSOR-BURNER SYSTEM, COMP RATIO=3
COMPRESSOR-BURNER SYSTEM, COMP RATIO=2
CONVENTIONAL GEAR DRIVE
RAM JET SYSTEM
NOTES: CURVES BASED ON FUSELAGE, STRUCTURE, ROTOR AND EQUIPMENT COMMON TO ALL SYSTEMS = 42 GROSS WEIGHT
ENDURANCE HOURS

FIG. 4. Comparison of jet and conventional helicopter performance.

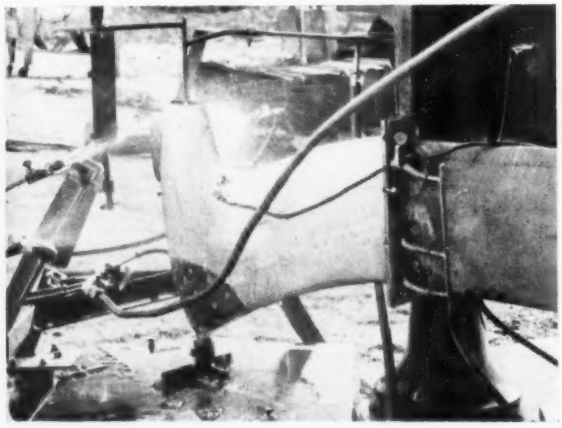

FIG. 5. Burner tests for compressor-burner helicopter rotor.

study it may be concluded that, performance wise at least, the pulse-jet helicopter appears to be the most interesting of the types of jet power plants now being considered.

(II) COMPRESSOR-BURNER JET ROTOR

At the time the above described analytical studies were first completed in a rough form, it seemed apparent to our Group that, even though the pulse-jet was clearly indicated as an interesting jet helicopter power plant, practical considerations prevented its use. At that time the pulse-jet had just been introduced to this country and existed only in a crude, bulky engine that was not in the least suitable for whirling at the end of a helicopter blade. Our work on ram-jet power plants indicated that the ram-jet helicopter could be accomplished without an impossible effort. On the other hand, the performance of the ram-jet helicopter was such that its commercial and military application seemed dubious. Accordingly, it was our decision to concentrate our efforts on the compressor-burner type of jet helicopter. Proposals were submitted in September, 1945. A contract from the Propeller Laboratory of the Air Materiel Command was received in April, 1946, calling for the design, construction, and test of a 20-ft. diameter, laboratory-type jet rotor.

The burner for this rotor as it was statically tested is shown in Fig. 5. This burner handled up to 1.2 lbs. air per sec. at fuel-air ratios of 0.03 to 0.10, producing reactions on the scales of as much as 80 lbs.

The completed rotor mounted on a test stand for whirling is shown in Fig. 6. Since this was only a laboratory device, compressed air for the tests was supplied by an Allison engine-driven supercharger. The rotor stand was constructed to permit measurements of the rotor lift. Power delivered to the rotor by the jet was determined as follows:

The rotor was driven without combustion, using the compressed air supply with measurements of the rotor speed, airflow, and air temperature. From this information it was straightforward to calculate the velocity of the air going through the known jet exit area and, hence, the jet thrust and power required to drive the rotor at various r.p.m.'s and blade angles.

Tests were conducted with the rotor at tip speeds up to 600 ft. per sec. and at total lifts over 1000 lbs., or more than 3 lbs. per sq. ft. of disc loading. In general, these tests substantiated the theoretical calculations for this type of rotor system. However, they also showed clearly that this rotor propulsion system was extremely sensitive to small losses in ducting pressure and combustion efficiency.

(III) RAM-JET WHIRL TESTS

Upon completion of the above described compressor-burner jet rotor in 1946, the company was faced with a decision regarding its next step in jet helicopter development. It was decided that the construction of a compressor-jet helicopter as a company-financed project would be too involved to undertake, partly because of the difficulties still existing in obtaining performance from the rotor system but mainly because of the unavailability of a lightweight efficient air compressor suitable for use with such a machine. An unsuccessful

FIG. 6. Air Force-Marquardt compressor-burner helicopter rotor.

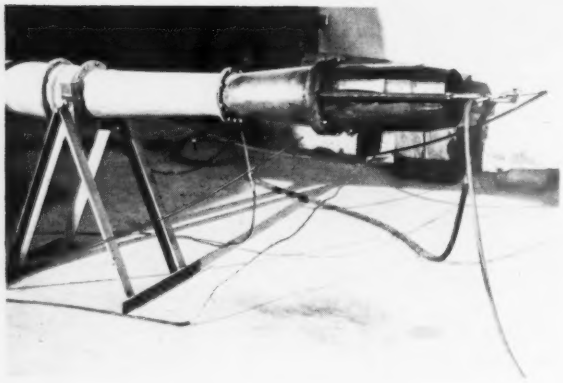

FIG. 7. Ram-jet tests for ram-jet helicopter.

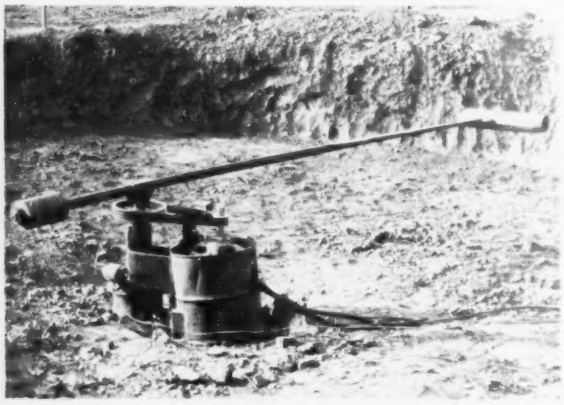

FIG. 8. Ram-jet whirl test.

attempt also was made to get the Government to finance a compressor-burner jet helicopter development program at the Marquardt Aircraft Company.

In view of the decision not to attempt a compressor-burner helicopter, it was decided in the Fall of 1946 to build a simple ram-jet helicopter largely to obtain experience with the flight characteristics of jet-driven machines. Accordingly, design of the M-14 helicopter was begun with the idea of using ram-jet engines for propulsion. It was decided from design studies that a $6\frac{1}{2}$-in. diameter ram-jet engine would be sufficient to power this machine.

Static tests of an internal flow model of the ram-jet engine were conducted at the Marquardt Aircraft Company plant during January and February of 1947. These tests were conducted with the model connected directly to the air supply, as shown in Fig. 7. The ram-jet engine so developed is shown in Fig. 8, as mounted on a simple whirling arm test setup. Whirl testing of this engine showed that the structural problems involved could readily be solved and that the performance of the engine would be satisfactory to fly the M-14 helicopter, the construction of which was then nearly completed.

(IV) Pulse-Jet Static and Whirl Tests

As discussed in Section I, it was believed from the first that a short pulse-jet engine that could be whirled would permit attaining nearly optimum jet helicopter performance. Unfortunately, no such engine was available. . Starting in December 1946, the Marquardt Aircraft Company obtained a great deal of experience with pulse-jet engines on U.S. Navy Contract NOa(s) 8520. Largely as a result of this experience, in October, 1947, we managed to develop an 8-in. diameter pulse-jet engine only 42 in. long, which appeared to be short enough to whirl. This engine is shown in comparison with a typical pulse-jet engine in Fig. 9. In the latter part of 1947 whirl tests were conducted on this engine using the same stand as used for ram-jet engine whirl tests. These were reasonably successful, and the design of the M-14 helicopter was changed as quickly as possible to permit the utilization of pulse-jet engines.

(V) M-14 Pulse-Jet Helicopter

The final M-14 helicopter as shown in Fig. 2 was designed as a simple, rugged machine. Wherever possible, surplus parts from other helicopters were used. The landing gear and parts of the control system, for example, were taken from a Sikorsky R-6. The hub design is essentially the same as that used by Bell. Actually, the only unique elements on the ship are the pulse-jet power plants and the method of directional control. The latter, as seen, is obtained with a rudder having its axis inclined at 45° to give response both in hovering and in forward flight.

FIG. 9. Comparison of pulse-jet engines: *left*, typical engine; *center*, 42-in. engine originally used on M-14 helicopter; *right*, 36-in. engine as finally developed.

FIG. 10. Examples of pulse-jet tailpipe collapsing and fatigue failures.

The machine has two items carried over from its original conception as a ram-jet-powered helicopter. The first was undesirable; the second, unnecessary. First: The blades with their NACA SH Series airfoil section and 0.043 solidity are somewhat too slim for the lower tip speeds required by pulse-jet power plants (about 450 ft. per sec. compared with 600+ for ram-jets). Second: A fairly complex gear box was built at the base of the rotor shaft to provide a means of starting the ram-jet rotor from an auxiliary external power supply, as well as to drive the fuel pump and tachometer.

Flight tests of this machine have been conducted under contract with the Propeller Laboratory of the Air Materiel Command. First tests were conducted at the Air Force Base, Muroc, Calif. Later tests have been made in the Los Angeles area. Tests to date have consisted of flights never above 15 ft. altitude and at speeds not exceeding 20 m.p.h. Turns have been made with great ease. In general, the aircraft appears to perform nicely, having good stability and ease of control. Vibration in the fuselage appears to be less than with conventional helicopters. The noise level is high but not much more objectionable than in gear-driven helicopters.

To date, flights of the aircraft have been limited only by the structural inadequacy of the pulse-jet power plant. This was anticipated and, of course, was the basic reason why the pulse-jet power plant was not adopted for this machine at a much earlier date.

In general, the pulse-jet has been beset by two types of structural failures: first, a collapsing failure resulting from the high centrifugal loads and extremely high temperatures of the metal in the tailpipe; second, failures have occurred due to fatigue cracks in the tailpipe. Examples of several failures are shown in Fig. 10.

Work in solving the collapsing problem has been primarily along the lines of reducing the length of the engine. Fig. 9 shows the 36-in. long engine now being used for the helicopter, as compared with the original power plant. Because of extensive performance tests, this engine actually puts out increased thrust and improved specific fuel consumption. It is believed that this length of engine will fairly well eliminate collapsing type failures in the range of tip speeds to be utilized.

Fatigue cracking of a tailpipe remains a serious problem. Basically, the centrifugal loads tend to throw the tailpipe into a heart-shaped cross section; whereas the explosion loads tend to expand it back into a circle, thus causing severe fatigue at various points around the periphery. Development tests are still under way to correct this type of failure.

(VI) Conclusions

Jet helicopters offer three intrinsic advantages. First and second: Because of the elimination of torque and mechanical transmission, the helicopter is greatly simplified and lightened. Third: Because of the basic characteristics of the jet power plant itself, a great deal of weight is saved, which, in combination with the above-mentioned weightsavings, result in machines capable of carrying extremely large pay loads.

Jet power plants are well adapted for either extremely small or extremely large helicopters. In the case of a small helicopter, the jet power plant provides reasonable pay load in sizes where efficient structures are difficult to accomplish. In the case of large machines, the direct drive of the rotor disc greatly simplifies the problems arising in the conventional machine due to torque and transmission difficulties.

Of the three jet helicopters considered in this paper, the pulse-jet drive offers the best load-carrying performance, being better than a ram-jet for all endurances and being about equal to the compressor-burner system for longer endurances.

The ram-jet helicopter appears to be feasible to develop in almost any size if such is desirable.

The compressor-burner jet helicopter seems to be feasible to develop but will require a good deal of straightforward engineering development, especially of rotor and compressor, before it can be utilized.

The pulse-jet helicopter is now in flyable condition. A good deal of work remains to be done in improving the structural adequacy of the pulse-jet power plants. When this is accomplished, the pulse-jet-driven helicopter offers the advantages of extreme light weight, simplicity, and minimum cost, combined with optimum load-carrying performance for jet-propelled craft.

Reference

[1]Denney, C. D., *Design Criteria for Jet-Propelled Helicopters*, A.S.M.E. Transactions, January, 1949.

I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

The Calculation of Coupled Modes of Vibration by the Stodola Method

By

Henry E. Fettis

Air Materiel Command, Wright Field

The present paper explains and illustrates the use of the familiar Stodola method of calculating natural modes of vibration as applied to coupled bending-torsion modes. At the present time two methods of computing coupled modes are in common use, these being the Rayleigh-Ritz method in which the uncoupled modes are first computed and then used as coordinates, with which the coupled modes may be approximated, and the influence coefficient method. The advantage of the Stodola method over the Rayleigh-Ritz method lies in the fact that it involves only slightly more labor than would be required to compute the uncoupled modes by the same method and also in the fact that the exact mode shape is found rather than an approximation of undetermined accuracy. Further, the necessity of solving the determinantal equation is done away with so that any additional work over that required to compute the uncoupled modes is more than made up for. The advantage over the influence coefficient method is that the work can be performed by a technically unskilled operator, whereas the influence coefficient method requires knowledge of matrix algebra. Also, the resulting matrix will be of order $2n$ for n stations on the wing, so that for large wings it may be necessary to employ mechanical means to evaluate the results.

Research on Aircraft Propulsion Systems*

By

Abe Silverstein

Lewis Flight Propulsion Laboratory, N.A.C.A.

The introduction in the past few years of many new aircraft-engine types has so greatly increased the scope of propulsion-system research that frequent assessments must be made of the problems and the goals, and the direction must be determined for the most fruitful application of a limited research effort. A method of analysis is outlined that enables aircraft-propulsion systems to be compared on a common basis, provides an ordered arrangement of the systems according to their use, and indicates the areas in which research effort should be expended to increase the performance of the systems. The results of extended analyses of this type are summarized, and the conclusions are reached that intensive research effort should be directed toward increasing (1) the compression ratios of gas-turbine engines, (2) the cycle temperatures of gas-turbine engines, (3) combustion efficiencies and intensities, and (4) the operating temperatures of heat-resistant materials. The fundamentals of these problems are discussed, and the research approach to their solution is outlined. Many problems of equal importance could not be mentioned because of the limitations of this presentation.

* Twelfth Wright Brothers Lecture, I. A. S., Washington, D.C., December 17, 1948.

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See pages 53 and 78 for Preprints that are immediately available.

Elastic Stability of Simply Supported Flat Rectangular Plates Under Critical Combinations of Transverse Compression and Longitudinal Bending

By

Norman Grossman

Republic Aviation Corporation

The elastic stability of a simply supported flat rectangular plate subjected to combined bending and compression was investigated theoretically in an effort to derive the correct interaction curves for various plate aspect ratios. By use of the Rayleigh-Ritz energy method, stability curves were obtained as a function of the plate a/b. The results indicate that the interaction equation recommended by ANC-5 is incorrect, yielding optimistic values for plates of $a/b < 1.05$ and conservative values in all other cases.

Propeller Flutter

By

M. J. Turner and James B. Duke

United Aircraft Corporation

A procedure is presented for the analysis of classical subsonic, torsion-bending flutter of propellers, extending the earlier work by Loring for nonrotating airfoils. Generalized coordinates and matrix notation are employed in the analysis; vibration modes of a nonrotating blade are employed as basic displacement shapes. Making certain simplifying assumptions in order to avoid entering into a discussion of the complexities of the most general case of coupled engine-

propeller system vibration, it is found that the flutter equations may be formulated for a single blade without loss of generality in considering the mechanism of flutter.

Because of initial twist, the blade elements undergo vibratory displacements in the direction parallel to the relative wind, creating additional lift forces and moments, which have been incorporated in the analysis. Theoretical expressions are derived for the required aerodynamic coefficients.

An iterative procedure is outlined for the calculation of flexural modes of a nonrotating blade. Because of the presence of centrifugal coupling terms in the equations of equilibrium, changes in mode shape with rotational speed are taken into account.

Interference Between Wing and Body at Supersonic Speeds by the Method of Characteristics

By

Carlo Ferrari

Cornell Aeronautical Laboratory, Inc.

The problem of interference between wing and body which was investigated in the first report of this series is again examined, but now, in contrast to what was done there, the small perturbation condition is eliminated; i.e., it is no longer required that the perturbations produced by the body and the wing in the uniform flow field be small enough to permit the linearization of the differential equation of the fluid motion. It is still assumed, however, that a potential field exists—a condition less restrictive than the previous one—and the determination of the flow is carried out under the assumption that the very tip of the nose is conical.

Since the free-stream velocity is supersonic, the field in the region ahead of the wing does not depend upon the presence of this appendage, and thus this phase of the study warrants the use of the method already propounded by the author in a previous report, to which, however, substantial modification and simplification are now applied. As in the first report of this series, the wing is assumed to extend beyond the region perturbed by the body, or at least it is assumed that the wing plan form is such that the tip phenomena due to the finite aspect ratio of the wing remain unaltered in presence of the body.

The determination of the fluid motion is accomplished through use of the hodograph method in derivation of the field corresponding to the conical nose and through application of the method of characteristics in the remaining regions.

Two-Dimensional Jet Mixing of a Compressible Fluid

By

S. I. Pai

Cornell Aeronautical Laboratory, Inc.

The mixing and divergence of a supersonic jet exhausting into a supersonic stream are investigated theoretically.

In the first part of this paper, the flow is assumed to be laminar. When the velocity and temperature in the jet are different slightly from those of the surrounding stream, by the method of small perturbations and under ordinary boundary-layer assumptions, the equation of motion of two-dimensional how will be reduced to a form of the well-known equation of heat conduction whose solution is known for any given boundary conditions. It has also been shown that the exact solution of the two-dimensional jet mixing of viscous compressible fluids can be obtained by successive approximations starting with the solution of small perturbations.

Velocity and temperature distributions for two cases—one the mixing of two uniform flows and the other the mixing of a jet of compressible fluid from a two-dimensional nozzle with full expansion exhausting into a supersonic stream—have been calculated. The properties of the jet mixing depend mainly on the momentum of the jet regardless of whether the change of momentum is due to the change of velocity or the change of temperature—i.e., the change of density. Compressibility has a considerable effect on the properties of the jet.

In the second part, the cases of turbulent flow are investigated. By means of Reichardt's theory of free turbulence the turbulent shearing stress may be expressed as

$$\tau = \rho\epsilon(\partial u/\partial y)$$

and

$$\epsilon = K\,(u_{max.} - u_{min.})h$$

It has been shown in this paper that

$$\epsilon = \epsilon_0\,(x/L)^n$$

where ϵ_0 is a constant that can be determined experimentally. The value of n lies between 0 and 1. The exact value of n depends on the condition of mixing.

When the expression of turbulent shearing stress given above is used instead of the viscous stress in the equation of motion, by suitable transformation of variables, it has been shown that the equation of two-dimensional turbulent jet mixing is identical to that of the laminar case. Hence, the solution of the first part of this paper can be applied to the turbulent case, provided that the characteristic constants ϵ_0 and n have been properly chosen.

Theories of Plastic Buckling

By

S. B. Batdorf

National Advisory Committee for Aeronautics

The theory for the plastic buckling of columns, which appears finally to have achieved a satisfactory form, rests upon the well-established uniaxial stress-strain relation. The development of a correspondingly satisfactory theory for the plastic buckling of plates has been hampered by the nonexistence of an established polyaxial stress-strain relation in the plastic range.

Present theories for the polyaxial stress-strain relation beyond the elastic range can be divided into two types, often called flow and deformation theories. Theories of plastic buckling based on deformation theories are in better agreement with experiment than those based on flow theories. On the other hand, tests in which a material is compressed into the plastic range and then subjected to shear at constant compressive stress are in better agreement with flow than with deformation theories. Legitimate doubt therefore has existed as to the validity of any theory for the plastic buckling of plates.

As a result of studying these apparent contradictions, a new theory of plasticity has been developed which is of neither the flow nor the deformation type. It is based upon the concept of slip, and its formulation was guided more by physical and less by mathematical considerations than previous theories. Experimental evidence of limited scope but of crucial character is in better agreement with the new theory than with either flow or deformation theories. The new theory accounts for the apparent contradictions previously alluded to and justifies the use of deformation theory in the analysis of plastic buckling problems.

Column Curves for Magnesium-Alloy Sheet

By
Evan H. Schuette
The Dow Chemical Company

Results are presented for flat-end tests of 129 columns cut from flat FS-1h, FS-1a, and Ma magnesium-alloy sheet 0.250 in. thick and for clamped-end tests of 26 columns cut from flat FS-1h sheet 0.064 in. thick. The best empirical fits to the data were obtained with the parabolic formula

$$\frac{P}{A} = KF_{cy} - \frac{(KF_{cy})^2(L'/R)^2}{4\pi^2 E}$$

with a horizontal cutoff at $P/A = F_{cy}$. Values of K for the several alloys were as follows:

FS-1h longitudinal	$K = 1.05$
FS-1h transverse	1.05
FS-1a longitudinal	1.10
FS-1a transverse	1.20
Ma longitudinal	1.00
Ma transverse	1.00

The tangent modulus column curve also provided good fits to test data for FS-1h and FS-1a but was overly conservative when applied to Ma. The failure to get good agreement for Ma may have been due to differences between the material used for column tests and that used in determining the tangent modulus or to differences in rate of loading between the column tests and the stress-strain curve determination.

All the test results were characterized by large scatter, probably a result of random out-of-flatness of the columns.

Performance Analysis of Centrifugal Compressors

By
Professor Shao-Pan Liang
Chekiang University, Hangchow, China

Elementary analysis of centrifugal compressors indicates that the energy received by each unit weight of gas compressed is merely a function of impeller tip speed. This, as shown by experimental results, is far from true. The pressure of delivery falls off with the increase of quantity of discharge, and the efficiency of compression is also affected. It is the purpose of this paper to point out that, based on force and energy calculations, performance can be predicted with reasonable accuracy.

A Method of Least Square Adjustment for Measured Wing Deflections

By
Dale R. Branchflower
Northrop Aircraft, Inc.

The dynamic characteristics of an airplane wing are predicted from calculations based on the theoretical bending-torsion modes of the wing. The validity of these predictions depends upon experimental verification of the theoretical modes. For this purpose measured wing deflections are obtained from ground vibration tests.

This paper applies the principles of least square adjustment to the measured modes in such a manner that a best fit is obtained for the kinetic energy. Furthermore, the measured deflections are expressed as a series of theoretical deflections. Probably the most important feature of the method given is that the coefficients in the series are a *numerical measure* of the similarity of theoretical and experimental modes.

Station Functions and Air Density Variations in Flutter Analysis

By
Manfred Rauscher
Massachusetts Institute of Technology

Station Functions have been devised as a means of correlating the motions of the masses at different stations in a vibrating system. The tie-in is analogous to that between the ordinates of a curve at a series of stations in the development of Simpson's Rule. The use of the Functions combines the conveniences of working with discrete masses and of having continuously defined deflections. The Functions are shown to serve well both for the calculations of vacuum modes and for the determination of flutter modes.

Air Density Variations have been considered as a means of fixing the flutter conditions corresponding to a chosen value of the flutter parameter k. The attractiveness of the scheme lies in its automatic coverage of the flutter performance at various altitudes and in its avoidance of calculations for hypothetical k's at air densities fixed in advance. The method becomes especially valuable when allowance is made for aerodynamic span effects, which greatly increase the labor of trial variations of k.

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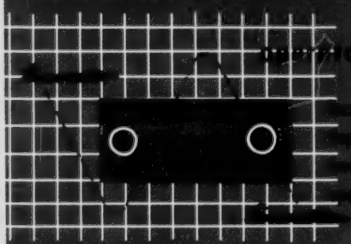

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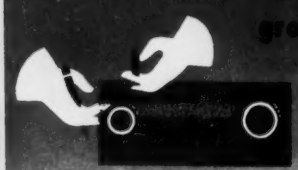

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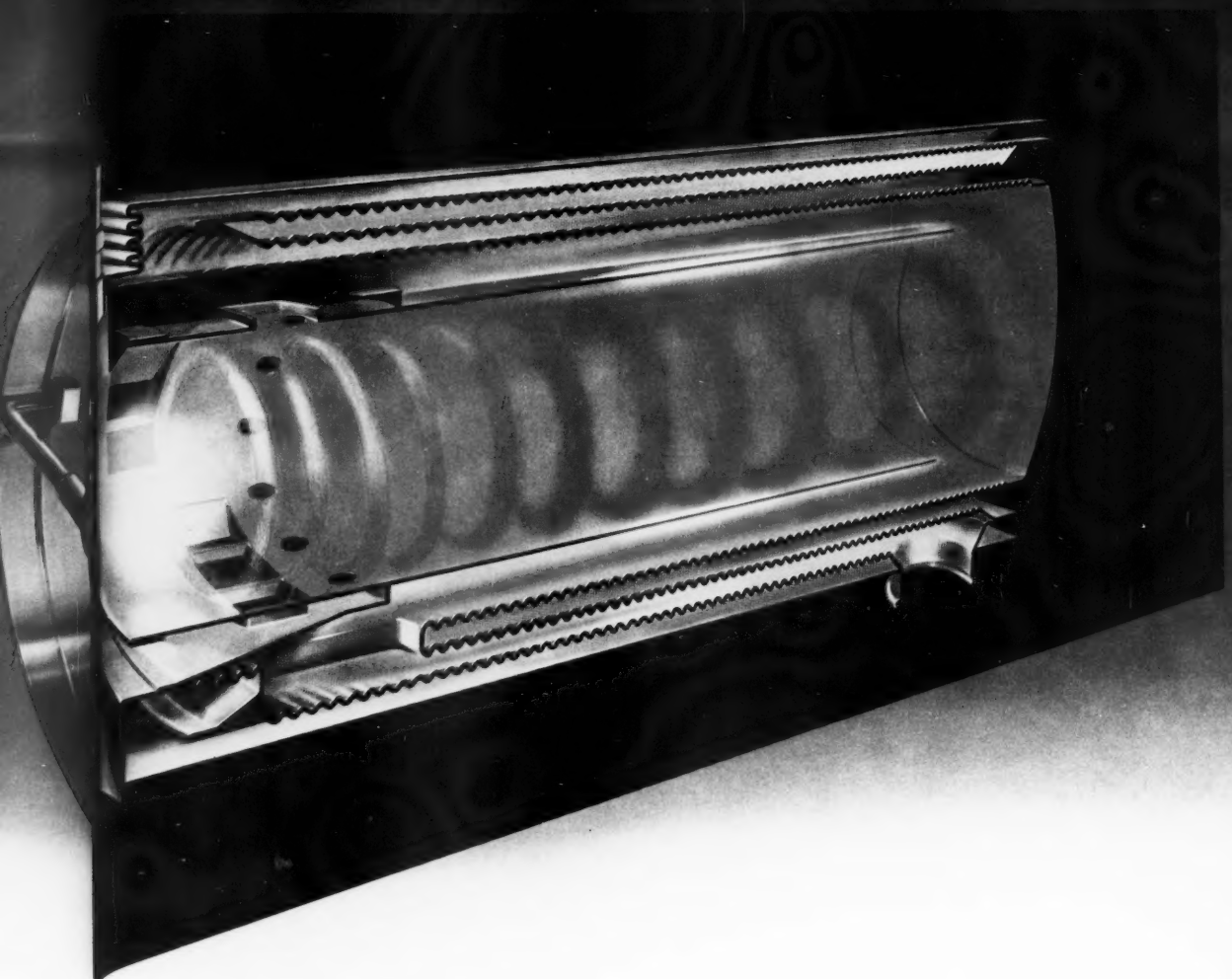

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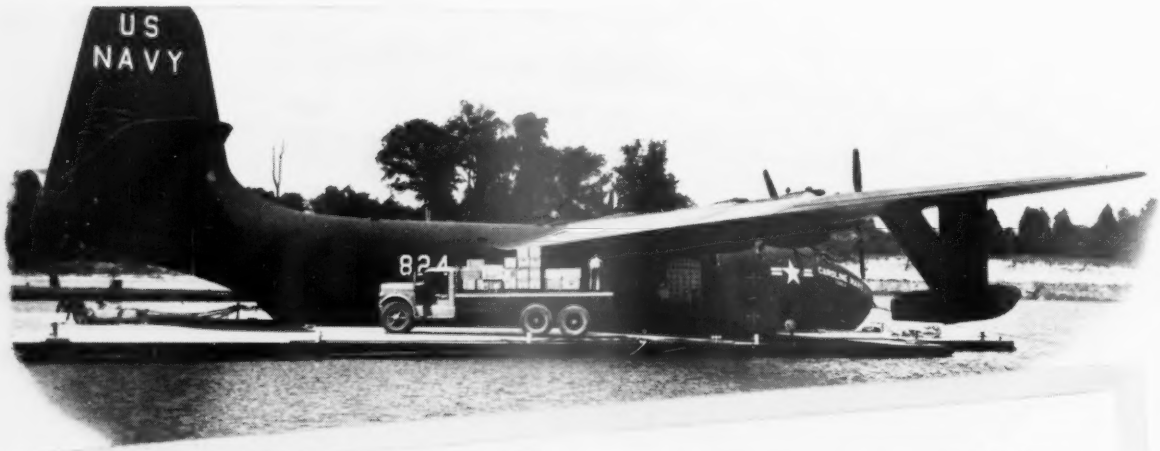

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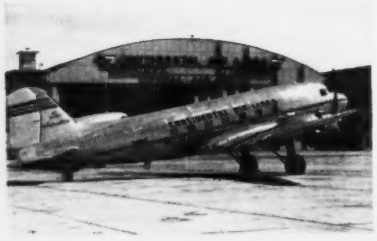

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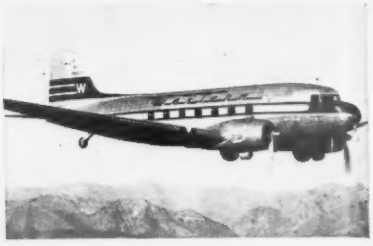

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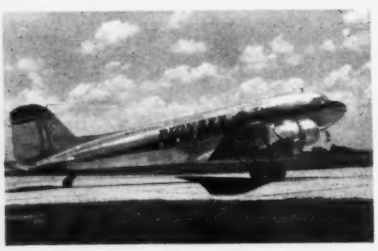

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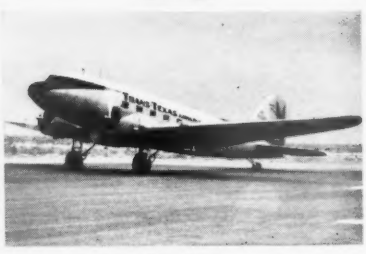

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Aerodynamics (2)

BOUNDARY LAYER

Investigation of the Interaction of Boundary Layer and Shock Waves in Transonic Flow. Hans Wolfgang Liepmann. *U.S., Air Force, Technical Report No. 5668 (A.T.I. No. 34705)*, February 9, 1948. 75 pp., illus., figs. 11 references.

Measurements of transonic flow past a 12 per cent thick circular arc profile for the interaction between shock waves and boundary layer; and the formation of shocks in transonic flow. Findings are: (1) The shock wave pattern at a given Mach Number can be completely altered by changing the boundary layer, (2) shock waves can interact with a boundary layer in a manner similar to the reflection of a wave from a free jet boundary, and (3) there exist two types of possible transonic flow past a given symmetrical boundary—one symmetrical about the maximum-thickness point and one asymmetrical about this point. The first can be identified with the known symmetrical potential solutions. In this case, recompression begins without a shock wave. The asymmetrical case is characterized by an expansion of the flow up to the shock wave. The shock wave in the symmetrical case is related to the "limiting" line of potential theory, the shock wave in the asymmetrical case to the shock waves occurring in Laval nozzles.

CONTROL SURFACES

Experimental Verification of a Simplified Vee-Tail Theory and Analysis of Available Data on Complete Models With Vee Tails. Paul E. Purser and John P. Campbell. *U.S., N.A.C.A., Report No. 823*, 1945. 21 pp., figs. 9 references. U.S. Govt. Printing Office, Washington. $0.20.

Results of the analysis of available data on vee-tail surfaces from an extension of previously presented vee-tail theory and from general comparisons of various characteristics of vee-tail and conventional tail surfaces. Probably no reduction in area will be provided, though a possible reduction in control forces is indicated. Advantages that can be obtained with a vee-tail designed to provide the same values of stability and control parameters as a conventional tail assembly are: less drag, less tendency toward rudder lock, reduction in elevator deflection required for take-off, keeping tail out of spray in flying-boat take-off, reduction of the possibilities of tail buffeting from the wing and canopy wakes in high-speed flight, and fewer tail surfaces to manufacture. Disadvantages tend to counteract the advantages of the vee-tail. The simplified theory of the vee-tail is valid for dihedral angles up to about 40°. The relative merits of the vee and conventional tails for spin recovery have not been established, but it appears that the vee-tail should be at least as good, except in cases where simultaneous full deflection of both rudder and elevator is required for recovery from the spin.

Consideration of Dynamic Loads on the Vertical Tail by the Theory of Flat Yawing Maneuvers. John Boshar and Philip Davis. *U.S., N.A.C.A., Report No. 838*, 1946. 5 pp., figs. 8 references. U.S. Govt. Printing Office, Washington. $0.10.

A comparison between the computed loads and the loads measured in flight on a fighter airplane, and the investigation on a large flying boat of the dynamic effects for both an abrupt rudder deflection and a sinusoidal rudder deflection. Conclusions indicate that: (1) when dynamic effects are considered, only a moderate amount of control deflection is necessary to reach the ultimate design load of the vertical tail surfaces of the flying boat; (2) the theory of flat yawing maneuvers provides a method for investigating dynamic loads on the vertical tail; and (3) in order that theoretical developments may provide a method for the determination of critical loads on the vertical tail, they must be accompanied by specifications of the yawing maneuverability required of the airplane.

FLUID MECHANICS & AERODYNAMIC THEORY

Linearized Compressible Flow. H. Poritsky. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 389–403, figs. 5 references.

Solutions of Laplace's equation find application in the study of linearized compressible flow. This linearized approximate theory of high-velocity flow is based on the assumption that velocity components, induced by an obstacle placed in a uniform stream of high velocity W_0, are small compared to W_0. Under this assumption, the velocity potential of the flow induced by the obstacle can

be shown to satisfy a differential equation that is also satisfied by other thermodynamic gas quantities. The equation holds for both subsonic and supersonic flow. Supersonic "conical" flows—i.e., flows in which the velocity components remain constant along straight lines through a point (the vertex or origin)—are produced by conical obstacles—i.e., solids whose boundary consists of straight lines through a vertex. To satisfy the assumptions of the linearized equation, the conical obstacle must lie close to the z-axis, or it may be a thin fin containing the z-axis and inclined at a small angle of attack to the main flow. The theory of conical flows is due essentially to A. Busemann.

On the Characterization of Fields of Diabatic Flow. B. L. Hicks. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 405–416. 4 references.

The introduction into flow equations of vector N as a vector proportional to V, the velocity vector for the steady flow of a compressible fluid. From the form of derived equations in N, language of the vector W yields simpler equations for rotational flow. The assumption of irrotationality of the N field leads to a number of new types of irrotational diabatic flow. These are illustrated by examining a number of flows of given character through the procedure of finding all functions for which the flow remains of a given type: elliptic, parabolic, hyperbolic, and mixed flows.

A Rapid Graphical Method for Computing the Pressure Distribution at Supersonic Speeds on a Slender Arbitrary Body of Revolution. Jim Rogers Thompson. *U.S., N.A.C.A., Technical Note No. 1768*, January, 1949. 24 pp., figs. 8 references.

A graphical computing technique developed from the linearized potential-flow equations of Jones and Margolis, with the simplifying assumption that an arbitrary body of revolution moving at supersonic speeds may be represented satisfactorily by a relatively small number of point sources and sinks. Pressure distribution of a parabolic body of fineness ratio 6 from ten sources and sinks agreed with the results of Jones and Margolis. Comparison with wind-tunnel measurements showed that the salient features of the pressure distribution were reproduced but that the minimum pressure peak was exaggerated and shifted to the rear. Although the results obtained with the point-source method were inferior to those obtained by the characteristics methods of either Tollmein or Sauer, the salient features of the pressure distribution were obtained in considerably less time.

On the Two Dimensional Steady Turbulent Flow of a Compressible Fluid Far Behind a Solid Symmetrical Body. I—(Momentum Transfer Theory). M. Z. Krzywoblocki. *Franklin Institute, Journal*, Vol. 247, No. 1, January, 1949, pp. 33–61. 26 references.

Complete tensor forms for the second and the third order stresses due to density fluctuations of the steady two-dimensional compressible turbulent flow in a wake far behind a solid symmetrical body are calculated completely for the first two approximations. From the third approximation, only the first equation was considered, because this was sufficient to show that the method may be used to obtain any desired degree of the approximation. The momentum transfer theory is used throughout in order that the velocity distribution may be compared with that obtained by the vorticity transfer theory.

On the Stability of the Supersonic Flows Past a Wedge. G. F. Carrier. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 367–378, fig. 5 references.

The perfect fluid theory is used to predict the stability of strong and weak shock-wave configurations when subjected to small time-dependent disturbances. A solution is made for the interaction of a plane acoustic wave downstream of a steady-stage shock. The wave impinges on the shock and reflects not as an acoustic but as an entropy and a vorticity wave. The solutions are those eigensolutions for which the amplitude of the acoustic reflection vanishes. On the basis that no self-excited oscillations can exist which vanish near the origin and that no nonsingular solutions obey the boundary conditions in the neighborhood of the origin, it is concluded that the flow configurations associated with a supersonic or subsonic downstream field are stable. J. I. Levinson's treatment of the same stability problem, which uses the small time-dependent-perturbation theory, gives conclusions that imply instability of all strong shocks and many weak shocks; these conclusions consistently are contradicted by experimental evidence. An explanation of the observation of weak shock in experimentation is that the weak-shock field has a small probability of approaching the region where the overall behavior is determined. In the strong-shock field, large disturbances are originally fed toward the origin, and unless such disturbances can be minimized sufficiently, the transition to the weak shock will follow.

NATURAL FLIGHT

Bird, Insect and Aeroplane Wings. H. Hull. *The Aeroplane*, Vol. 75, No. 1958, December 17, 1948, pp. 756–758, 761, illus., figs. The manner in which birds and insects obtain lift and propulsion, and a comparison of their efficiency with that of an airplane.

PARASITIC COMPONENTS & INTERFERENCE

Calculations of Air Flow in the Vicinity of Fuselages. F. K. Schmidt. (*Deutsche Forschungsanstalt für Segelflug Ernst Udet, Ainring*, July, 1945.) *U.S., Air Force, Translation No. F-TS-2615-RE (A.T.I. No. 19130)*, May, 1948. 25 pp.

The determination of the velocity field around an arbitrary aircraft body, not necessarily rotationally symmetrical, in a laminar flow. By considering the body to be a deformed ellipsoid and the flow about it to be a distorted ellipsoidal flow and by using the methods of displacement calculation, a series is obtained to express the flow. The terms of this series are simple and finite, and the first two terms may be used as a first approximation.

STABILITY & CONTROL

Wind-Tunnel Investigation of a $^1/_{20}$-Scale Powered Model of a Four-Engine Transport Airplane. Victor I. Stevens, William M. Douglass, and Jules B. Dods, Jr. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. A-94)*, May and July, 1944. 97 pp., illus., diagrs., figs., fold. charts. 4 references. Investigation of empennage and control-surface effectiveness, the effect of propeller rotation on longitudinal stability, and the best method of carrying spare wing panels under the fuselage.

THERMO-AERODYNAMICS

A Note on One Dimensional Fluid Dynamics. Knox Millsaps. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 1, January 1, 1949, pp. 13–21. 29 references.

The conditions of flow at a point on a streamline in nondimensional form in terms of an initial set of conditions and mass, momentum, and energy changes. The conventional treatment of one-dimensional gas dynamics using the concept of a perfect gas is extended to the more exact equations of stage of Van der Waals and Beattie-Bridgeman.

Air Transportation (41)

Purchase of Aircraft. William P. Hildred. *Indian Aviation*, Vol. 32, No. 10, October, 1948, pp. 304–307. Aircraft investment risks invite creation of international credit facilities by IATA.

1948: Biggest Year for Nonskeds. Charles Adams. *Aviation Week*, Vol. 50, No. 1, January 3, 1949, pp. 32, 33. Mileage, passengers carried, load factors, revenues, and operating expenses of individual U.S. uncertificated carriers during 1948.

The Commercial Basis of Air Transport. Peter G. Masefield. *Aeronautics*, Vol. 20, No. 1, December, 1948, pp. 24–29, fig. (Extended summary of a paper.)

India's Services to the Far East. *Indian Skyways*, Vol. 2, No. 11, November, 1948, pp. 21–23, 25, 27.

Pakistan Civil Aviation. *Indian Aviation*, Vol. 32, No. 10, October, 1948, pp. 309–312.

A brief statistical survey of the Department of Civil Aviation from January to June, 1948. Includes: personnel and training, maintenance facilities, licensing, airports, communications, and foreign transport agreements.

TATA and Indian Aviation. *Indian Aviation*, Vol. 32, No. 10, October, 1948, p. 314.

Freighting Lore: Air Mail—2. H. W. Ainsley. *Airports & Air Transportation*, Vol. 3, No. 66, December, 1948, pp. 155–159, illus.

Livestock by Air; An Expanding Freight Traffic. J. A. Peden. *Airports & Air Transportation*, Vol. 3, No. 66, December, 1948, pp. 171–173, illus.

What's Ahead for Air Express in 1949? Kinsey N. Merritt. *Air Transportation*, Vol. 13, No. 6, December, 1948, pp. 16, 17, 46.

U.S.-Caribbean Air Cargo. II. Guy Reed Cassell and R. W. Hoecker. *Air Transportation*, Vol. 13, No. 6, December, 1948, pp. 12–15, 40–42, illus.

Aircargo Trends. John H. Frederick. *Distribution Age*, Vol. 48, No. 1, January, 1949, pp. 23, 48, 49, fig. Speed and facile handling as they promote the establishment of air transport as an essential function in the nation's distributing process.

Produce Unaffected in Pressure Tests. *Aviation Week*, Vol. 50, No. 1, January 3, 1949, p. 35.

Air-borne fruits and vegetables require controlled temperature and humidity. Quality is otherwise unharmed by normal conditions of flight. Study by the U.S. Department of Agriculture and the Lockheed Aircraft Corporation.

Air Cargo Flight Forms and Records. II. Richard H. Rush. *Aviation Maintenance & Operations*, Vol. 11, No. 2, January, 1949, pp. 32, 33, facsimiles.

Western Drops Free Meals. Terrell Drinkwater. *Airports and Air Carriers*, Vol. 15, No. 1, January, 1949, pp. 10, 11, illus.

The Flight Companion. Harold B. Pereira. *Aeronautics*, Vol. 20, No. 1, December, 1948, pp. 36, 37, illus. Publicity material given to passengers of the British Overseas Airways Corporation, American Overseas Airlines, Swedish Airlines (ABA), Air France, and Pan American World Airways.

Searching for Oil in Iran by Air. *Aviation Week*, Vol. 50, No. 3, January 17, 1949, pp. 45, 46, illus.

Airplane Design & Description (10)

AIRPLANE DESCRIPTIONS

New Jet Aircraft for the USAF. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 1, January 1, 1949, pp. 6, 7, illus.

The Lockheed XF-90 two-engined penetration fighter, Republic XF-91 single-engined interceptor, Consolidated Vultee XF-92 *V*-wing interceptor, McDonnell XF-88 twin-jet penetration fighter, Northrop XF-89 all-weather jet night fighter, and Northrop X-4 flying laboratory.

Soviet Aircraft; Russian Developments Have Produced Jet Airplanes of Top-Notch Quality. *Ordnance*, Vol. 33, No. 172, January-February, 1949, pp. 248–251, illus. World War II fighters and bombers: Yak-3, -9, and Lavotchkin-7, -9 fighters. Jet fighters and bombers include: the new Yak-( ), -15; Mig-7 research fighter, and a version of the German DFS-346, the IL-four-jet and Tupolev twin-jet bombers.

Italian Newcomers (Caproni Ca A.V.S. Two-Engined Instrument and Night-Flying Trainer, Caproni Ca 193 Two-Engined Personal Airplane, Macchi M.B. 320 Two-Engined Six-Place Monoplane, and the SAI-Ambrosini P.512 Freighter). *The Aeroplane*, Vol. 75, No. 1960, December 31, 1948, pp. 820, 821, illus., diagrs.

Sweden Swings to Jets. William Green. *Canadian Aviation*, Vol. 22, No. 1, January, 1949, pp. 26, 27, 44, 46, illus.

A Ferocious Breed; Hitting Power and "Toughness" Characterize the Modern Line of Single-Seat Strike Aircraft. *Flight*, Vol. 55, No. 2089, January 6, 1949, pp. 3–5, illus.

Two Prospective Military Trainers (Beech Model 45 Single-Engined Mentor and Douglas XT-30 Single-Engined Trainer). *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 66, illus.

Jet-Propelled Lightplane. Hugh G. Nicholson, Jr. *Flying*, Vol. 44, No. 1, January, 1949, pp. 24, 25, 71, illus. One-place and two-place personal airplanes designed and fabricated at Cal-Aero Technical Institute.

Pacemakers of Progress; A Brief Description of Some of Those Outstanding Technical Developments of the Last 25 Years Which Have Been Pioneered by A.W.A. Engineers. *Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton Nr. Coventry, England*, 1948. 31 pp., illus., diagrs.

"Apollo" (A.W. Mark I) (Armstrong Whitworth), A New Civil Transport With Four Gas Turbines. *Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton Nr. Coventry, England*, 1948. 17 pp., illus., diagrs.

Bonanza Trying for Distance Mark; Beech Plane, With Odom at Controls, Fitted With Wingtip Fuel Tanks for Hop From Honolulu to New York City. Alexander McSurely. *Aviation Week*, Vol. 50, No. 1, January 3, 1949, pp. 13, 14, illus.

No-Damage Belly Landing. *Aero Digest*, Vol. 58, No. 1, January, 1949, p. 48, illus. Landing of the Beech Model 34 Twin-Quad on muddy ground, using emergency stainless-steel landing skids built in along the underside of the fuselage.

Development of the (Boeing) Stratocruiser. *Aviation Week*, Vol. 49, No. 24, December 13, 1948, pp. 29–31, 33, illus. Changes in the original specifications for the Boeing 377 Stratocruiser as a result of collaboration by Pan American Airways' engineers with the Boeing staff.

'49 Filton Fashion (Bristol Brabazon I). *Flight*, Vol. 55, No. 2089, January 6, 1949, pp. 11–13, illus.

New Wing Ups Cessna 170 Performance. Alexander McSurely. *Aviation Week*, Vol. 50, No. 2, January 10, 1949, pp. 35, 36, illus.

New Chase (YC-122) Transport Avitruc Stresses High Utility. *Aviation Week*, Vol. 50, No. 1, January 3, 1949, pp. 18, 20, 21, 24, illus.

Light Plane's Test Pilot, Stanley Orton Bradshaw, Reports on the Goodyear Duck (GA-2 Amphibian). *The Light Plane and Private Owner*, Vol. 2, No. 9, December, 1948, pp. 14–16, illus., diagr.

New 2-0-2 Cargo Plane Announced. *The Martin Star*, December, 1948, p. 5, illus., fig.

Airliner—Jr. Size (Monsted-Vincent Starflight). Don Andrews. *Skyways*, Vol. 8, No. 2, February, 1949, pp. 26, 27, 45, 59, illus.

USAF Reveals Remotely Controlled Target Plane OQ-19A (Radioplane Company). *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 2, January 15, 1949, p. 5, illus.

Sportplane Priced Under $5,000; Modified Single-Seat Racer (Schweizer Midget Mustang). Alexander McSurely. *Aviation Week*, Vol. 50, No. 3, January 17, 1949, pp. 51, 52, illus.

Flying the Motor-Tutor (Slingsby T-29A). *The Aeroplane*, Vol. 75, No. 1959, December 24, 1949, pp. 798, 799, illus., diagr.

Progress of Vickers Viscount (Transport); Second Prototype Under Construction; Promising Performance Figures. *Modern Transport*, Vol. 69, No. 1552, December 25, 1948, pp. 5, 20, illus.

Civil Aircraft in Review: Vickers Viscount. *Airports & Air Transportation*, Vol. 3, No. 67, January, 1949, pp. 200–204, illus.

BODY GROUP

Development of a Sandwich-Type Cargo Floor for Transport Aircraft. L. A. Yolton. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1550-C*, October, 1947. 46 pp., illus., figs. 2 references.

Simulated-service and basic-strength tests of two cargo floors consisting of a sandwich of 75ST aluminum face sheets and a core of maple plywood bonded to a layer of resin-treated paper honeycomb. In one floor the maple plywood was five ply, 5/32 in. thick. In the other it was seven ply, 7/32 in. thick. Results were compared with those obtained from tests of a floor that consisted of a flat aluminum-alloy sheet spot-welded to a corrugated aluminum-alloy sheet with flat tops and webs inclined to the vertical and from tests of a floor that consisted of a flat aluminum-alloy sheet spot-welded to a double-dimpled aluminum-alloy base sheet. Although the seven-ply sandwich floor was heavier than the aluminum floors and although both sandwich floors were inferior to them in flexural strength and under concentrated-load tests, it equalled or exceeded the performance of the aluminum panels in the impact, rolling-load, and strip-load tests and were rated superior to the aluminum floors.

Tests of Cargo Flooring M for Aircraft. L. A. Yolton. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1550-B*, April, 1947. 31 pp., illus., figs.

Simulated-service and basic-strength tests were made on aluminum-alloy-sheet wearing surfaces spot-welded to single and double-dimpled layers of the same material. This type of cargo floor is, in general, inferior to floors constructed of aluminum-alloy sheet that was spot-welded to a corrugated base consisting of flat tops with a web inclined to the vertical. It is also inferior to a similar floor in which the base had square corrugations.

Tests of Cargo Flooring R and S for Aircraft. J. A. Liska. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1550-E*, June, 1948. 25 pp., illus., figs. 3 references.

Simulated-service and basic-strength tests of aluminum-alloy sheet wearing surfaces spot-welded to an undersurface containing small closely spaced corrugations. With undersurfaces formed from aluminum sheet 0.047 and 0.040 in. thick, this construction gave floors with performance superior to all other types except the sandwich-honeycomb construction. The superiority is attributed to the better load distribution of the closely spaced corrugations.

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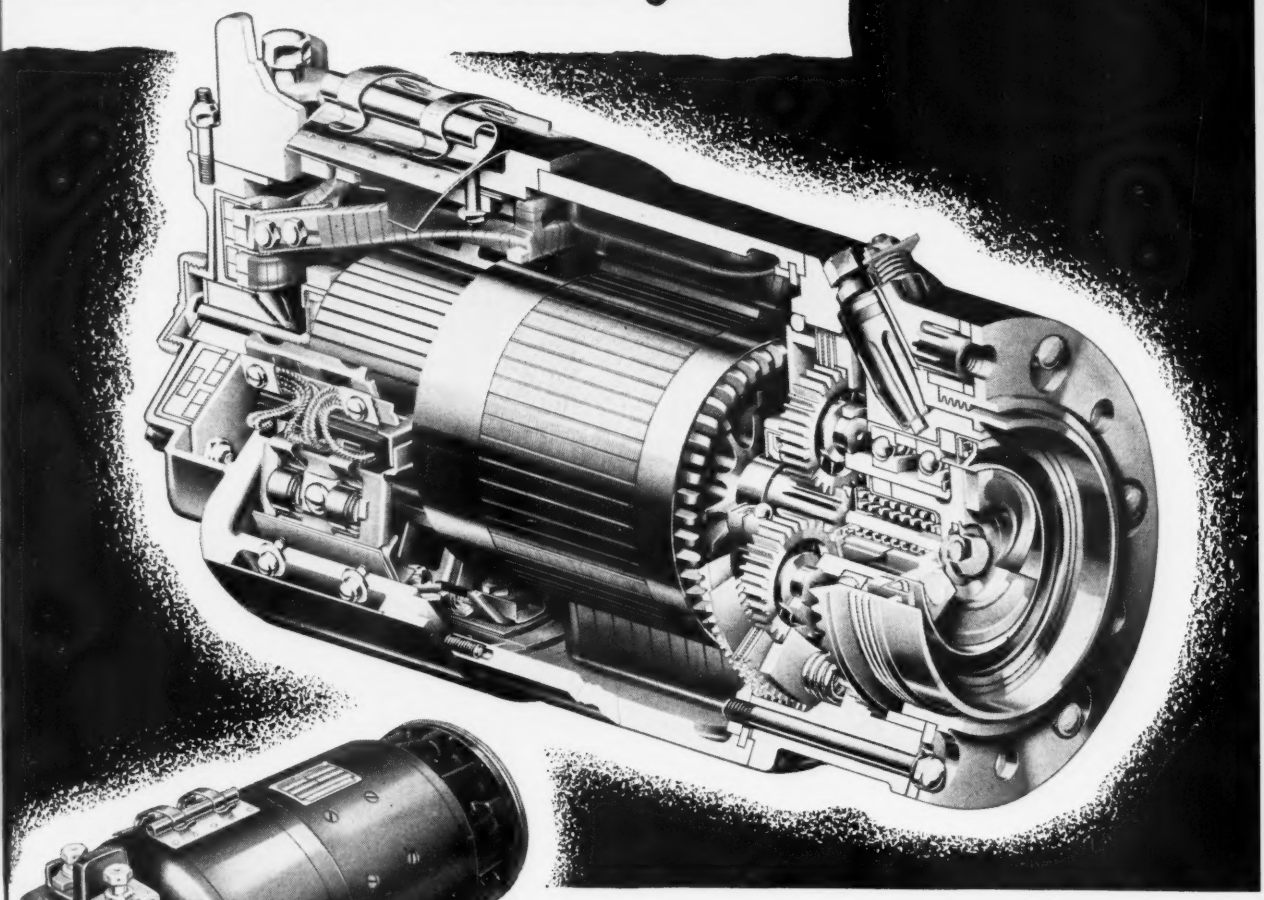

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CONTROL SYSTEMS

Powered Controls. D. J. Lyons. *Flight*, Vol. 54, No. 2087, December 23, 1948, pp. 759–761, figs. (Extended summary of a paper: Present Thoughts on the Use of Powered Flying Controls in Aircraft.)

FUEL TANKS

Bladder Type Fuel Cells. *Shell Aviation News*, No. 125, November, 1948, pp. 18, 19, illus. Relative advantages of bladder and integral fuel cells, and the construction, fabrication, installation, maintenance, and physical and chemical properties of the Mareng cells produced by the U.S. Rubber Company under license from The Glenn L. Martin Company.

LANDING GEAR

A New Angle on Landings. *Aircraft and Airport*, Vol. 10, No. 12, December, 1948, pp. 23, 24, illus. The Goodyear cross-wind landing gear.

PRELIMINARY DESIGN

Airplane for Water Landings. Alfred B. Herb. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 38, 39, diagrs.

The incorporation of retractable steps into a streamlined fuselage, as that on the Republic Rainbow, to absorb shock loads during landing and take-off, and to perform the primary function of providing planing surfaces to produce lift. Four steps will be used, two located so that their center of lift will be equidistant fore and aft of the center of gravity. A third will be near the bow for rough-water protection, and the fourth will be two-thirds of the distance from the rear main step to the aft end of the fuselage. Constituting 10 per cent of the hull length and 70 per cent of the hull's lower lateral circumference, the step will conform with the outer contours of the hull when retracted for flight. Spray strips at the front of the fuselage are the only compromise from a true streamline form. This seaplane design, if proved practical, could equal landplane flight performance.

Tunner Outlines 'Ideal' Cargo Plane. John Christie. *Aviation Week*, Vol. 50, No. 3, January 17, 1949, pp. 16, 17, illus.

Specifications for a cargo airplane and auxiliary cargo-handling and maintenance accessories suggested by the staff of the Berlin Airlift. Efficiency of aircraft in operation has been found to be proportional to their cargo capacity.

American Jet Transport Trends. A. Marthason. *The Aeroplane*, Vol. 75, No. 1959, December 24, 1948, pp. 790–793, illus., diagrs., figs.

Jet Propulsion in Civil Aircraft. *The Aeroplane*, Vol. 75, No. 1959, December 24, 1949, pp. 794, 795. 1 reference.

WINDSHIELDS

Daily Bird-Plane Collisions Show Windshield Weaknesses. Pell Kangas and George L. Pigman. *SAE Journal*, Vol. 57, No. 1, January, 1949, pp. 54–59, illus., diagr., figs. (Extended summary of a paper: Development of Aircraft Windshields to Resist Impact With Birds in Flight.)

C.A.A. tests on impact-resistant materials and mounting methods show that one type of pane that is superior to all others is one that has glass faces and a thick polyvinol butyral plastic interlayer that extends beyond the glass edges on all sides for bolting to the mounting frame. After failure of the glass faces, this plastic edge forms a flexible membrane with high tensile strength and elongation. Such a sheet absorbs considerable energy before failure. Resistance of a windshield varies approximately as the logarithm of pane thickness, and it is the thickness of the butyral plastic interlayer which determines primarily the impact strength of this type of windshield. The angle of impact on the windshield panel greatly affects its impact strength, which varies approximately as the secant of total angle of panel slope. Size and shape affect strength but slightly, yet high strength is associated with large panel size. Although superior to other types, the glass-plastic windshield has several recurrent types of failure. Optical properties vary with ratio of glass-to-plastic thickness, and the thickness of each glass face should equal that of the plastic interlayer to obtain normally acceptable characteristics. Splinters are stopped by a thin, hard plastic sheet, but it is generally broken by the distortion of the plastic interlayer and, in addition, has undesirable optical properties. Panel mounting bolts should be spaced at least two bolt diameters from the edge of the panel. In general, small bolts at close spacing provide more uniform support than large bolts at wide spacing.

Glass in Aircraft. A. C. Waine. *Aeronautics*, Vol. 20, No. 1, December, 1948, pp. 38–40, diagrs.

The strength characteristics of sheet, plate, and laminated glass used in aircraft; the design of bird-proof windshields; and windshields in which a hot-air sandwich, a dry-air sandwich, or electric heating elements are used to prevent the accumulation of mist and frost.

Airports & Airways (39)

Delays in Landing of Air Traffic. T. Pearcey. *Royal Aeronautical Society, Journal*, Vol. 52, No. 456, December, 1948, pp. 799–812, figs. 1 reference.

In randomly arriving traffic, the probability that a particular aircraft will suffer a controlled delay is proportional to the degree of saturation of the airport—i.e., the ratio of the minimum safe-landing interval to the mean arrival interval. For small degrees of this saturation, the average delay is small but increases rapidly with increasing saturation. The average delay equals the mean arrival interval for a degree of saturation equal to 0.75. At this point, the probability of delay suddenly falls and then continues to decrease. An upper limit for the probability of a long delay is deduced. A true estimate of the required handling capacity of an airport can be obtained only from a criterion based upon knowledge of distribution of delays. The estimation of airport size cannot be based alone upon the allowable fraction of aircraft delayed and the average delay, but it must also take into account a more important factor—the fraction of the total aircraft to be allowed to suffer protracted delays beyond a specified figure.

Traffic Control for Jet Transports. Warren T. Dickinson. *SAE Journal*, Vol. 57, No. 1, January, 1949, pp. 68, 69, figs. (Summary of a paper: Traffic Control Requirements for Jet Transport Aircraft.)

ANDB (Air Navigation Development Board) to Develop New Navigation Aids. *Aviation Week*, Vol. 50, No. 1, January 3, 1949, pp. 10, 11.

Airport Surface Movement Detection, an Airport Approach Control Timer, and an Interim Private Line Visual Communications System. Operational requirements for additional devices include: (1) an air-borne display for symbolic air traffic control data, (2) a flight path planning element, (3) a display for detail flow control, (4) airport time utilization equipment, and (5) an air-borne transponder for use with the private line communications system.

Air Power and Air Bases. S. D. Sturgis, Jr. *The Pegasus*, January, 1949, pp. 6–9, 16, illus.

The wheel loadings of current and proposed military aircraft require runways that are impractical for army engineers to construct in overseas theaters. Structurally competent concrete runway pavements must be more than 20 in. thick. Even if the penalty in combat efficiency imposed by multiple-wheel and track landing gear is accepted in order to permit flexible pavements to be used, the foundations that are called for may be 72 or more inches thick, according to the character of the subgrade.

Effect of Engine Vibration on Runways. Walter R. Macatee. *Airports and Air Carriers*, Vol. 15, No. 1, January, 1949, p. 16, illus.

Airport Use Charges—How Should They Be Figured? *Aviation Maintenance & Operations*, Vol. 11, No. 2, January, 1949, pp. 21–25. The Idlewild Airport leases. A statement of the position of the Port of New York Authority and of the position of the scheduled air lines.

Airport Financial Management—Local Level. Leigh Fisher. *Aviation Maintenance & Operations*, Vol. 11, No. 2, January, 1949, pp. 39, 49, 50. Relations between the municipal government and the airport operator.

Night Landing Lights for Helicopters. *Airports & Air Transportation*, Vol. 3, No. 66, December, 1948, p. 168, illus.

What's New in Taxiway Lighting. Leslie C. Vipond. *Aviation Maintenance & Operations*, Vol. 11, No. 2, January, 1949, pp. 26–28, 61, illus., diagrs.

Schematic diagrams of series and multiple taxiway-lighting circuits using individual small-size regulator assemblies and individual transformers for each taxiway section or a single large

transformer; and description of the L-822 and the L-825 elevated runway lights.

Westchester's New High Intensity Lights. Robert C. Blatt. *Airports and Air Carriers*, Vol. 15, No. 1, January, 1949, pp. 6, 7, illus.

Let Your Lights Shine Out. Frank W. Spence. *Airports and Air Carriers*, Vol. 15, No. 1, January, 1949, pp. 12, 33, illus. Removal of snow from runways equipped with elevated lights.

Snow Removal Procedure for Port Authority (New York) Operated Airports. *Airports and Air Carriers*, Vol. 15, No. 1, January, 1949, pp. 17, 18, 20–23, 36, illus., figs.

Airports of the World: Alderney, A Pattern for "Miniaturization." Basil C. de Guérin. *Airports & Air Transportation*, Vol. 3, No. 66, December, 1948, pp. 169, 170, illus.

Airports of the World: Hurn, London Alternate and BOAC Base. *Airports & Air Transportation*, Vol. 3, No. 67, January, 1949, pp. 193–195, illus.

Atomic Energy (48)

Atomic-Powered Plane Hurls Challenge at Engineers. Andrew Kalitinsky. *SAE Journal*, Vol. 57, No. 1, January, 1949, pp. 44–47, figs. (Extended summary of a paper: Atomic Power for Aircraft Propulsion.)

Aviation Medicine (19)

How Much Force Can Body Withstand? Charles F. Lombard. *Aviation Week*, Vol. 50, No. 3, January 17, 1949, pp. 20, 21, 23–25, 27, 28, fig. 12 references.

Physiological limits of toleration to forces induced by velocity changes. Acceleration, the rate of velocity change, affects the mass constant in terms of multiples of weight. An acceleration of two gravitational units doubles the weight, while one of three units triples the weight, etc. The effect of weight increase upon the body is dependent upon the amount, direction, duration, and surface area upon which it acts; the physical characteristics of the tissues involved; and the height of the column of blood between the heart and the brain, measured in the direction of force. Since the magnitude of the force increases while duration of application decreases, there is a transition into the field of wounding by missiles. For conditions of force with greater duration and area, factors of tolerance are the diminishing of the height of the column of blood through positional changes, straining of the muscles of the legs and abdomen, and the use of protective pressure suits. Positional changes, as they affect the maximum human tolerance, are charted as lines intersecting conditions of positive and negative accelerations.

Crash Deceleration, Crash Energy, and Their Relationship to Crash Injury. *Cornell Committee for Air Safety Research, Crash Injury Research*, December 29, 1948. 6 pp., illus. Structures designed for greater energy absorption and controlled acceleration, in conjunction with shoulder harness and more effective safety belts, will cut crash dangers in private aircraft.

Informative Accident No. 7. *National Research Council, Crash Injury Research*, May 7, 1948. 6 pp., illus.

A free fall from a height of 145 ft., which subjected a man to an impact of 150–200g, and an airplane collision in the air at 100 ft. caused only minor physical injury to the victims. The ability of the human body to sustain decelerations from 100g to 200g for a brief period, if the force is distributed over a large area of the body, indicates that airplanes can be designed which would protect the occupants from serious injury in crashes.

A Report of Physiological Changes Occurring in Respiratory Alkalosis at Sea Level and Altitude. William N. Crowson and Harry T. Linger. *Contact*, Vol. 6, No. 4, July, 1948, pp. 17–23, illus., figs. 13 references.

Respiratory alkalosis with signs of tetany can readily be induced by voluntarily hyperventilating atmospheric air under ambient sea-level conditions and in the low-pressure chamber at simulated altitudes of 10,000, 15,000, and 18,000 ft. The symptoms produced by 10 min. of hyperventilation are severe enough to produce considerable impairment of coordinated movements and much mental cloudiness, which, under conditions of flight, would cause considerable difficulty in the proper control of the aircraft.

An Investigation of Prediction of Success in Naval Flight Training. Jacob E. Finesinger, Stanley Cobb, Eliot D. Chapple, and Mary A. B. Brazier. National Research Council, Committee on Aviation Psychology. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 81*, October, 1948. 313 pp., illus., diagrs., figs.

Predicters of success in flight training based on psychiatric interviews and on physiological and psychological measurements. Areas of investigation were interviews based on topics commonly used to obtain evidence for clinical diagnosis of psychoneurosis; ratings of the subject's behavior characteristics while dealing with intimate material; measurement of verbal and gestural activity by means of "Interaction Chronograph"; physiological functions in the resting state and during and after auditory stimulus; electroencephalographic tracings; various types of projection tests, including an abbreviated Rorschach and a modification of the Morgan-Murray thematic apperception test; and handwriting as a characteristic type of continuous, coordinated, and integrated muscular activity. Positive correlations were obtained with the Interaction Chronograph, the respiration variables, the Thematic Apperception Test, the Five-Word Test, and the Picture Arrangement Test. The correlations were subjected, uncorrected, to a further tryout on an independent sample to provide a cross validation. Results were generally negative. Conclusions are that measurements from these tests do not predict success in flight training.

Appendices to an Investigation of Prediction of Success in Naval Flight Training. Jacob E. Finesinger, Stanley Cobb, Eliot D. Chapple, and Mary A. B. Brazier. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 82*, December, 1948. 163 pp., illus., figs., tables. Detailed directions for the administration of tests employed in the original Squantum study, *Report No. 81*.

Meet the Average Airman. *Aeronautics*, Vol. 20, No. 1, December, 1948, p. 41, diagrs. Drawings showing the dimensions of the "standard" man established by the British Ministry of Supply. From *Air Publication 970*.

Comfortization (23)

Pilot "Bed" Developed for Prone Position. *Aviation Week*, Vol. 49, No. 24, December 13, 1948, p. 35.

A Nylon hammock shaped to the human form suspends the pilot in a prone position. Tests conducted by the Aero Medical Laboratory, Air Materiel Command, show that this position can be maintained for as long as 8 hours without discomfort.

The Design of Airplane Interiors. Walter Dorwin Treague. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint.* 5 pp.

The designer of airplane interiors will strive for maximum seating comfort and a psychologically pleasant but not obtrusive environment in all aircraft. As the size of aircraft and the duration of flight increase, these efforts must be intensified, and more attention should be given to relieving monotony and providing ease of movement and some circulation, diversions, and a variety of environment. If these latter objectives are achieved, airplane travel will compare favorably with the slower and heavier but, at present, more luxurious forms of transport.

Interior Treatment of Aircraft. John J. Harrington. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint.* 10 pp.

The design, layout, soundproofing, surface covering and finish, convenience facilities, interior decoration of the cabins of commercial aircraft, and the diversion provided during flight are determined not only by the limitations of the aircraft configuration, weight, and center-of-gravity location but also by the physical requirements and the psychological reactions of the passengers. The aircraft designer, in order to provide maximum passenger comfort, must integrate his work with that of the physiologist and psychologist on human preference; appreciation; perception of color relationships, light values and textures; and noise-level acceptability.

Stratocruiser (Boeing): Built for Comfort. *Aviation Week*, Vol. 50, No. 2, January 10, 1949, pp. 22, 23, 25, 26, 28, 29, illus., diagr., table.

General layout and details of facilities, fixtures, appointments, accessories, and illumination of the main cabin, galley, dressing rooms, and flight deck of the Boeing Stratocruiser; the characteristics, components, and design of the pressurization, air-conditioning, humidity-control, and the a.c. and d.c. supply and distribution systems. Provision has been made for maintenance and inspection during flight. The rudder control system has virtually no lag and does not respond to aerodynamic forces.

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Compartments are provided for 820 cu.ft. of cargo and 350 cu ft. of baggage. A diagram locates the 44 maintenance and service access panels. Includes tabulation of basic design data for the individual air-frame components and basic design and performance data for the aircraft and power plants.

The "Sleeperette." *Shell Aviation News*, No. 125, November, 1948, pp. 23, 24.

Modification of the Douglas DC-4 for sleeper passenger operation. Full reclining seats with a combination leg-rest-table assembly designed and manufactured by Pan American Airways eliminated the need for berths and their accessories.

Operational Engineering; Cockpit Coolers. *Skyways*, Vol. 8, No. 2, February, 1949, pp. 44, 53, illus., diagr. A simple air-cycle refrigerating system developed by AiResearch Manufacturing Company for cooling the atmosphere of pressurized aircraft cabins.

Education & Training (38)

Vision Unlimited. *Naval Aviation News*, No. 20, December, 1948, pp. 13–17, illus.

Classroom television; an automatic approach, cruise, and landing system utilizing the angle of attack; a panel of indicators of engine functions; an attitude indicator in which the simulated plane rather than the artificial horizon moves with change of direction; and an alertness indicator that measures the electrical current set up by muscle action and audibly signals a danger point of slowed reactions due to fatigue are in stages of development at the Special Devices Center, Sands Point, L.I.

Electronics (3)

Transitional Avigation Aids. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 17, 92, diagr.

Brief descriptions of elements of air-traffic control and navigation to be completed and in operation within the next 5 years: Omnirange; Distance Measuring Equipment (DME); course-line computer; Instrument Landing System (ILS); precision beam radar (GCA); surveillance radar; lightweight receiver; and approach lights.

Precision Flight Control. I—The System. *Aviation Maintenance & Operations*, Vol. 11, No. 2, January, 1949, pp. 30, 31, 54, 55, diagrs. The operation of the Bendix Flight Path Control system in the Instrument Landing System.

Radio Commentary; A Survey of Available Communication Equipment. *Airports & Air Transportation*, Vol. 3, No. 67, January, 1949, pp. 205–208, illus.

Lear Packages Lightplane VHF. *Aviation Week*, Vol. 50, No. 1, January 3, 1949, pp. 30, 31, illus. The Lear Omnimatic communications and navigation set.

Lear Introduces "Omnimatic." *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 22, 101, 102, illus.

Fundamental Principles of Ionospheric Transmission. G. Millington. The Inter-Service Ionosphere Bureau. *Gt. Brit., Department of Scientific and Industrial Research, and Admiralty, Radio Research Special Report No. 17*, September, 1943 (1948). 82 pp., figs. British Information Services, New York. $0.55.

A descriptive theoretical exposition of the underlying principles of the transmission of radio waves through the ionosphere. The successive stages in the development of the theory are traced from the initial observations that indicated some kind of reflecting shield surrounding the earth and from deductions as to the nature, structure, and properties of the region to the experimental confirmation of the existence and nature of the ionosphere. Calculations of the modes of refraction that take place in successive layers of differing conductivity, the effect of the angle of projection on the propagation of radio waves, and the influence of sunlight on the ionosphere and the effect on communications serve as a basis for the determination of the actual heights of the various layers in the ionosphere and as a background for short-wave communications operating procedure. The use, for simplicity, of the ray concept to explain all phenomena requires that the problems of long-wave transmission around the earth and the behavior of wave guides for microwaves be omitted. In order to serve the widest circle of readers, the use of mathematics has been kept to a minimum, and discussion has been excluded of both the practical side of the designing and operation of apparatus for making ionospheric measurements and of the detailed experimental results that have been obtained.

PROCEEDINGS

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A Theory on Radar Reflections From the Lower Atmosphere. W. E. Gordon. *Institute of Radio Engineers, Proceedings*, Vol. 37, No. 1, January, 1949, pp. 41–43. 13 references.

Radio Interference Suppressed in Crash Rescue Boat P-268. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 24, December 15, 1948, pp. 7–9, diagrs.

The grounding and shielding installed in a U.S.A.F. Crash Rescue Boat P-268 to reduce radiated and conducted communications-signal interference produced by the craft's electrical equipment. The basic system was developed by the Interference Reduction Unit of the A.M.D. at Watson Laboratories, Red Bank, N.J.

RF Signal Generator Developed for Air Force Field Use (General Electric TS-413 (XA-A)/U). *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 2, January 15, 1949, p. 6, illus.

Interphone Amplifiers—Equipment Evaluated at AMC. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 1, January 1, 1949, p. 5.

Performance characteristics of Interphone Amplifier AM-147(XA)/AIC and Mounting MT-516(XA)/AIC; Interphone Amplifier BC-709-( ) and Interphone Equipment RC-73. Summary of findings in AMC Engineering Division Memorandum Reports *MCREE-4847* and *4848* indicate that operation is satisfactory under normal conditions. Redesign is recommended.

A Coaxial-Line Support for 0 to 4000 Mc. R. W. Cornes. *Institute of Radio Engineers, Proceedings*, Vol. 37, No. 1, January, 1949, *Waves and Electrons Section*, pp. 94–97, figs. 5 references.

Communication in the Presence of Noise. Claude E. Shannon. *Institute of Radio Engineers, Proceedings*, Vol. 37, No. 1, January, 1949, pp. 10–21, figs. 10 references.

Engineering Practices (49)

Dimensions Standardized by World Lines. *Aviation Week*, Vol. 49, No. 26, December 27, 1948, pp. 18, 19. Aerial navigation dimensional units for messages transmitted by aeronautical stations under the jurisdiction of the International Civil Aviation Organization will be standardized in 10 years' plan.

Equipment

Protecting Machine Parts With Dust Excluder Boots. Watson G. Harding. *Product Engineering*, Vol. 20, No. 1, January, 1949, pp. 106–110, illus., diagrs., figs. Includes application on aircraft actuating devices and landing-gear struts.

ELECTRICAL (16)

Dynamoter "Canned" for Altitude Efficiency. *Aviation Week*, Vol. 50, No. 3, January 17, 1949, p. 38, illus.

Unit developed by the Bendix Aviation Corporation, Red Bank (N.J.) Division, is hermetically sealed in an ordinary No. 2 can, the kind used for foods, under sea-level atmospheric conditions. The can is manufactured by the American Can Company.

Fundamentals of AC Circuit Interruption. III—Transient Recovery Voltage. Erwin Salzer. *Allis-Chalmers Electrical Review*, Vol. 13, No. 4, Fourth Quarter, 1948, pp. 18–23, illus., figs.

HYDRAULIC & PNEUMATIC (20)

A Completely Nonflammable Aircraft Hydraulic Fluid. B. B. Farrington, N. W. Furby, and J. M. Stokely. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint*. 8 pp., illus.

A halogenated nonaromatic hydrocarbon with corrosion inhibitors has been developed by the California Research Corporation. It is a fire extinguisher rather than a fire promoter and has a low-temperature viscosity comparable with present petroleum-base hydraulic fluids meeting AN-0-366. New types of rubber available for seals with this fluid remain compatible with mixtures containing up to 50 per cent of present AN-0-366 fluids before shrinkage of the seal takes place. Although its high specific gravity may decrease the pay load in long-range flights and it requires handling precautions similar to those observed for carbon tetrachloride and other industrial chlorinated compounds, the fluid solves the problem of low-temperature operation of aircraft hydraulic systems and is completely nonflammable in normal use, in crash conditions, and under the hazards of military operation. The high lubricity of the fluid indicates its possible application in the lubrication of jet and turbojet engines in which similar problems of low-temperature operation, highly loaded gears, and potential fire hazards are found.

Evaluation of Non-Flammable Hydraulic Fluids. Fred O. Hosterman. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint*. 7 pp., figs.

In the program for the development of nonflammable hydraulic fluids, three have been tested which offer a compromise with the target characterstics and can be considered as interim fluids. One, a water-base fluid, has poor low-temperature viscosity, corrodes magnesium, and, in the vapor phase corrodes steel. Another, with an ester base, is unsatisfactory for use with standard packings. The third fluid consists of the standard mineral base to which a halogenated compound has been added to extinguish flames. It has a flammability equal only to the reference fluid, HS-1, and its price is prohibitive. A fourth fluid that is undergoing tests belongs to a class of compounds that have a completely halogenated base and may eventually supply the final nonflammable hydraulic fluid. Although its cost is not excessive, its weight would introduce a considerable penalty in aircraft operation, and it would require the development of packing materials other than the elastomers now in use.

Non-Flammable Hydraulic Fluids. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 56, 92, illus. Skydrol by Douglas Aircraft Company and Monsanto Chemical Company, RPM Fluid by Standard Oil Company of California.

Hydraulic Pumps and Motors; How to Analyse and Predict Their Performance Under Widely Varying Conditions of Operation. Warren E. Wilson. *Machine Design*, Vol. 21, No. 1, January, 1949, pp. 133–138, illus., figs.

Flight Operating Problems (31)

HIGH-SPEED FLIGHT

Jet Engines Accent Vapor Trails. Robert McLarren. *Aviation Week*, Vol. 50, No. 1, January 3, 1949, pp. 24, 25, illus. The causes of the vapor trails produced by high-speed aircraft.

PILOTING TECHNIQUE

Fighters for the Flattops. J. N. Murphy. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 34, 35, 96, 100, illus. Operating procedures for carrier-based jet fighters.

Winter Flying Tips for Skiplane Pilots. *Canadian Aviation*, Vol. 22, No. 1, January, 1949, pp. 32, 42, illus.

REFUELING IN FLIGHT

Refuelling in Flight. C. H. Latimer-Needham. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint*. 80 pp., illus., diagrs., figs.

Equipment and technique used by Flight Refueling, Ltd., and a comprehensive analysis of the economic and operational advantages afforded by flight refueling in commercial and military aircraft operations. A history of the technique is included. The profitable operation of long-range commercial transport aircraft requires a pay load equal to approximately one-half the disposable load and approximately one-quarter the gross weight of the aircraft. Typical present-day aircraft, under these conditions, would have a still-air range of about 3,000 miles, which, with flight refueling, would be an adequate stage length for most world air routes. With the adoption of this refueling practice, the development of disproportionately large aircraft for long-range flights would be unnecessary, and pay load would be directly proportional to aircraft size. Transport airplanes could be standardized and would be able to operate from existing airports; no increase in the load-carrying capacity of the runways would be necessary. The fixed cost of ground installations along air routes would be reduced. By adjusting the amount of fuel transferred during refueling, the pay load on reciprocal flights could be equalized, and errors in weather prediction could be compensated. The elimination of intermediate landings would not only reduce operating costs but would increase average flight speed and aircraft utilization. General specifications are given for three long-

range aircraft, refuelable in flight and accommodating 50, 75, and 100 passengers and weighing 100,000, 130,000, and 160,000 lbs. gross, respectively. The projected performance characteristics on three routes—London to New York, London to Bermuda, and London to Sidney—are given for these aircraft when powered by four different types of power plants: reciprocating engine and propeller, turboprop, turbojet, and a compound compression-ignition and turbine engine driving a propeller. A method of route analysis is developed in detail. The formulas for calculating fuel and pay load that are obtained can be used to assess the advantages afforded by flight refueling on any particular air-line route.

Flight Safety & Rescue (15)

The Function of Safety Belts in Crash Protection. *National Research Council, Crash Injury Research*, February 20, 1948. 4 pp.

Tests conducted by the Naval Medical Research Institute showed that safety belts can provide a snubbing action at the hips that exceeds 2,000 lbs. Analysis by the Crash Injury Research Project of light airplane accidents showed that survivors whose safety belts failed seldom suffered visceral injuries and that fatal injuries in survivable accidents were caused almost entirely by the head striking solid or rigid objects. Parts of the body that are held by the belt and forced to decelerate at the same rate as the aircraft structure can tolerate decelerations of forward velocity between 20*g* and 30*g*. The number of fatal injuries in survivable accidents could be reduced by increasing the holding capacity of safety belts and their attachment fixtures, by providing anchorage points for a pilot's shoulder harness, and by using a yielding material in structures within striking range of the head.

Pilot Ejection at High Speed. James E. Sullivan. *Western Flying*, Vol. 29, No. 1, January, 1949, pp. 12, 13, illus., fig.

The force exerted by the catapult designed by the Naval Air Material Center to eject pilot and seat from high-speed aircraft reaches the maximum that is consistent with human safety in the shortest period of time which will not excite a significant dynamic response. Since force is maintained during the remainder of the ejection stroke, all points on the seat and occupant are accelerated uniformly, and the resultant maximum response factor is one. Practical installation of the catapult in aircraft requires that the cockpit be laid out so as to provide sufficient clearances for the ejection without impairing control accessibility or the pilot's field of vision. Suitable disconnect fittings must be developed for the pilot's oxygen supply line, headphone and transmitter leads, and the supply line of the antiblackout suit.

Correspondence: Aircraft Accidents. J. Smith. *Royal Aeronautical Society, Journal*, Vol. 52, No. 455, November, 1948, pp. 762–764.

The functions and jurisdiction of the senior airport control officer and the flight captain of an aircraft during assisted landings and during safety drills for crew and passengers. Materials that may become a source of flammable vapor in a crash are enumerated, and designs are suggested which will prevent their release. Safety precautions to be observed in the design of ignition systems are included.

Flight Testing (13)

Air Flow. *Machine Design*, Vol. 21, No. 1, January, 1949, p. 87, illus.

Visualization in flight of airflow over aircraft surfaces by Goodyear Aircraft Corporation. Movement of taped 4-in. four-ply knitting yarn indicated the direction of flow. Moving-picture camera studies taken during normal stall show the turbulence beginning over the inboard portion of the wing and progressing steadily outboard to the slot.

Clocking Speed to a Whisker. *The Martin Star*, December, 1948, pp. 4, 17, illus. Photographic and electronic techniques used by the Air Force at Muroc, Calif., to measure accurately the flight speed of aircraft.

Sonic-Speed Midgets. J. H. Lemelson. *Skyways*, Vol. 8, No. 2, February, 1949, pp. 28–31, 60, 61, illus. The use of free-flight and pick-a-back models by the N.A.C.A. to investigate the flight characteristics of full-scale aircraft.

Fuels & Lubricants (12)

Synthetic Liquid Fuels From Hydrogenation of Carbon Monoxide. I—Review of Literature; Bureau of Mines Research on Effect of Catalyst Preparation, Reduction, and Induction Procedures on Activity; Correlation of Physical Properties of the Catalysts With Their Activity. H. H. Storch, R. B. Anderson, L. J. E. Hofer, C. O. Hawk, H. C. Anderson, and N. Golumbic. *U.S., Bureau of Mines, Technical Paper No. 709*, 1948. 213 pp., illus., diagrs., figs. U.S. Govt. Printing Office, Washington. $0.50.

Gliders (35)

"Tadpole" Wing Uses Boundary Suction. *Aviation Week*, Vol. 49, No. 24, December 13, 1948, p. 25, illus.

Glider tests conducted by the Australian Council for Scientific and Industrial Research in the development of thick airfoils with suction boundary-layer control. Basic profile design was advanced by A. G. Griffith.

Per Ardua Ad Cumuli; Specially Designed Glider Winch at Redhill. F. G. Irving. *Flight*, Vol. 54, No. 2087, December 23, 1948, pp. 756, 757, illus.

Guided Missiles (1)

Aerodynamic Symmetry of Projectiles. C. G. Maple and J. L. Synge. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 345–366. 1 reference.

A mathematical investigation of the restrictive influence of symmetry upon the instantaneous motion of a projectile. Any state of motion of the projectile, for consequences of n-gonal rotational symmetry about an axis and of reflectional symmetry of the projectile in a plane, is described graphically in terms of (1) the positive components of velocities of a base point O and the angular velocity of the projectile, which are related to themselves and to a corresponding aerodynamic force system by means of axes perpendicular to an origin at O, and (2) an angle of the covering operation. Upon equating for surviving coefficients of the aerodynamic force system in cases of vanishing cross-spin and vanishing axial-spin, and in the case where both cross-spin and axial-spin vanish, it is found, in summary, that the principal part of axial torque has dependence on the yaw and the angle of the covering operation and is periodic in the angle with a period $\alpha = 2\pi/n$. The formula presented holds true even in the degenerate case $n = 1$ when there is no rotational symmetry but only reflectional symmetry.

What Is Happening in the Field of Rockets, Jet Propulsion, and Supersonic Flight. Joseph T. McNarney. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 2, January 15, 1949, pp. 15–21. Future American development of the guided missile and its tactical facilities.

The Expendable-Tank Step Rocket. Kenneth W. Gatland. *Aeronautics*, Vol. 20, No. 1, December, 1948, p. 40, diagr.

A chemical-fuel rocket in which the fuel is supplied to the propulsor from the rearmost of a series of tanks. The fuel flows from the forward to the rear tanks as it is consumed. Tanks are jettisoned when empty.

Navy Reveals Ramjet Missile. *Aviation Week*, Vol. 49, No. 3, December 6, 1948, p. 16, illus.

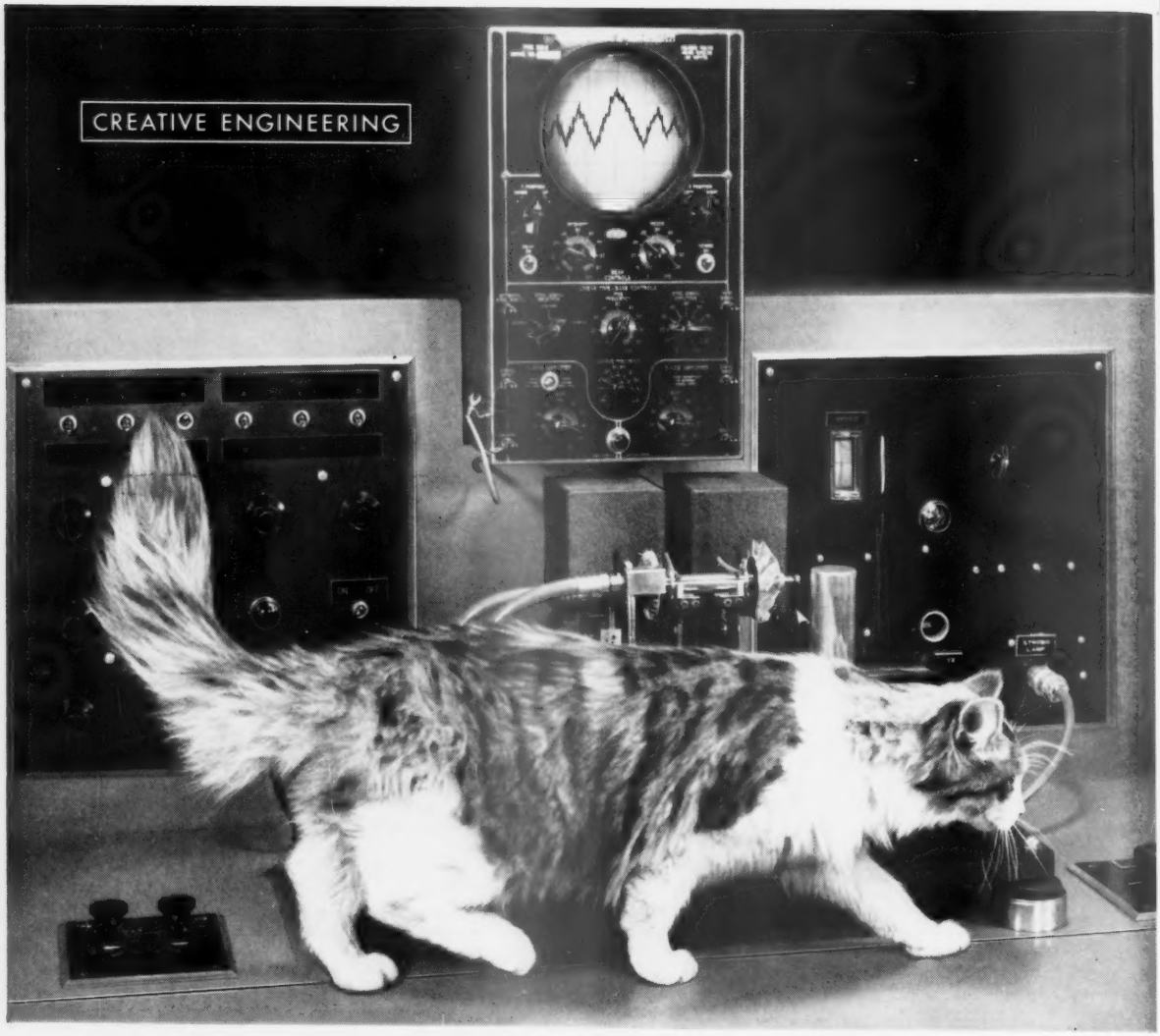
Design, test flight, and performance of the Martin Gorgon IV, a radio-controlled, air-launched, subsonic missile powered by a 20-in. Marquardt ram-jet engine. Flight data are transmitted to a ground station by multichannel telemetering equipment. A parachute assembly is provided for recovery of the missile.

Gorgon IV, Ram-Jet Engine Test Missile Completes Successful Flights for Navy. *The Martin Star*, December, 1948, pp. 3, 17, illus.

Instruments, Aircraft (9)

Manual Control Stability Through the (Sperry) "Zero Reader." Ira F. Angstadt. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 58, 59, 87, 88, illus., figs.

An analysis of the design of the Sperry Zero Reader equipment, its relationship to the aircraft's standard flight instruments, and the quality of the flying attained with its use in level flight and in low minimum approaches.



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The Zero Reader (Sperry). Wolfgang Langewiesche. *Air Facts*, Vol. 12, No. 1, January 1, 1949, pp. 47–65, figs. Flight control using the Sperry Zero Reader compared with that using standard instruments.

New Zero Reader (Sperry). Carlyle H. Jones. *Airports and Air Carriers*, Vol. 15, No. 1, January, 1949, pp. 8, 36, illus., diagrs.

Safety Flight Level Indicator. *Aircraft and Airport*, Vol. 10, No. 12, December, 1948, p. 27, illus.

A combined compass and altimeter display that indicates the proper altitude in an air lane which will ensure 1,000-ft. separation in altitude between opposing air traffic. In one type of display, each quadrant of a remote-reading compass dial is calibrated additionally for 500 ft. of altitude; an altitude pointer, barometrically controlled, revolves once for each 2,000 ft. of altitude. When an aircraft has attained the prescribed lane for its direction of flight, the altitude pointer indicates the additional number of feet that must be gained or lost to reach the flight altitude proper to the aircraft heading. When the proper level is reached, the compass and altitude pointers coincide. During ascent or descent the correct flight level can be maintained at all times by climbing on a clockwise and descending on a counterclockwise turn. In a second type of display, the flight level altitude is mounted separately from the remote-reading compass, preferably alongside. The instruments were invented by Basil W. Cocks and have been tested by the Australian Council for Scientific and Industrial Research.

A New Type of Electrical Instrument. Keats A. Pullen. *Instruments*, Vol. 21, No. 11, November, 1948, pp. 1008–1011, illus., figs. 1 reference.

An a.c. dial-and-pointer current-measuring instrument that employs a double moving-coil system is resistant to shock and vibration and is substantially more sensitive than conventional repulsion-iron and dynamometer types. An experimental model has a torque-to-weight ratio of 225 dyne per cm. per rad. per Gm.

Laws & Regulations (44)

Realignment of the Domestic Airline Route Pattern. I. Louis E. Black, Jr. *Journal of Air Laws and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 409–433.

Examination of Civil Aeronautics Board opinions in which the transfer of certificates of public convenience and necessity has been considered. For purposes of purchase and transfer, values are assigned to the certificates by carriers. The Board is faced with the problem of determining whether the assignment of such a value is suitable to public interest. Administrative decisions permitting the transfer of certificates in other public utilities under regulatory acts may lead to a conclusion about the plausibility of the Board's position regarding transfer of certificates and a suggestion for the maintenance of flexibility of the route pattern.

Legal Problems in Revising the Air Route Pattern. Joseph J. O'Connell, Jr. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 397–408.

Point of view of the Chairman of the Civil Aeronautics Board on the financial plight of domestic trunk-line carriers. The increase in competition which accompanied postwar certification was partially undesirable, yet a restrictive policy would have been a serious error. A presently proceeding C.A.B. analysis of domestic route patterns will yield a classification of bad competition situations, and it is through changes in these patterns that an improved financial condition will evolve. Powers held by the Board to effect changes are to approve or disapprove transfers and mergers and to alter and suspend certification.

Re-Ordering the National Air Map—How Can It Be Accomplished Under the Civil Aeronautics Act? Alan F. Wohlstetter. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 466–474.

Stewardship of the Airlines by the Civil Aeronautics Board. William A. Patterson. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 390–396. Policies of the Civil Aeronautics Board as they affect air-line progress.

The Revocation of an Airline Certificate of Public Convenience and Necessity. Oswald Ryan. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 377–389.

Economic regulation that provides for reconsideration of Civil Aeronautics Board decisions, if construed as an instrument for the revocation of a certificate of public convenience and necessity which was already lawfully issued and by its own terms in effect, would be inconsistent with the express terms of section 401 (g) and (h) of the Civil Aeronautics Act.

1948 Report of American Bar Association Committee on Aeronautical Law. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 448–455.

Special Committee on Uniform Aeronautical Code, Report to the National Conference of Commissioners on Uniform State Laws. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 456, 457.

Judicial Review of Orders of Cab Which Require Approval by the President. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 474–480.

Paramount Public Interest in International New Route Cases. Francis T. Crowe. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 480–487.

Review of Federal Aviation Activities. Walter H. Wager. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 442–447.

Lighter-Than-Air (40)

Airships in the U.S. Navy. C. E. Rosendahl. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 26, 27, 102, 104, 105, illus. A report to substantiate a separation of airship administration from Naval Aviation.

Machine Elements (14)

AUTOMATIC CONTROL

Selecting Electric Servomotors. Robert S. Edwards. *Machine Design*, Vol. 21, No. 1, January, 1949, pp. 104–109, illus., figs.

Important design considerations that must be taken into account in making a choice of mechanical rotation servomotor: (1) ratio of maximum stalled torque to inertia, (2) type of data system or error-measuring device, (3) power, (4) size and weight, and (5) service. A conventional shunt-connected d.c. motor can be used, but associated equipment is generally large and heavy. Two types of motor-generator d.c. servomotors often used are the Ward-Leonard drive, which can be used to produce a high-performance servomechanism, and the Amplidyne, which obtains an electromagnetic amplification that allows the machine to be controlled with a small amount of power in the control fields and permits use well into the integral horsepower range. For a.c. servomotors, two-phase induction motors with a good torque-inertia ratio can be designed for either 60 or 400 cycles per sec., and they find use in ground and aircraft work; amplifier size limitations generally restrict their use to servos rated at less than $^1/_{10}$ hp.

BEARINGS

Superprecision Ball Bearings. III—Selection for Low Friction, Rigidity and Load Capacity. Thomas E. Rounds. *Machine Design*, Vol. 21, No. 1, January, 1949, pp. 97–103, figs.

FASTENINGS

King Fastener. *Flight*, Vol. 54, No. 2087, December 23, 1948, p. 757, diagr. Cowling fastener by the King Aircraft Corporation, Hillington, Glasgow.

(Clips, Clamps, and Line-Support Blocks for Aircraft and Industrial Use.) *Thomas Associates, Catalog*, January 1, 1949. 25 pp., diagrs. Specifications for bus bar, angle bracket clips, structural angle brackets, shim-plate nuts, support clamps, electrical-harness clamps, and block clamps.

How to Design Round-Bar Clamps. Louis Dodge. *Machine Design*, Vol. 21, No. 1, January, 1949, pp. 115–120, figs. 3 references.

Unified Screw-Thread Standards. *Machine Design*, Vol. 21, No. 1, January, 1949, pp. 127, 128, 182, figs.

FRICTION

The Incremental Friction Coefficient—A Non-Hydrodynamic Component of Boundary Lubrication. J. T. Burwell and C. D. Strang. *Journal of Applied Physics*, Vol. 20, No. 1, January, 1949, pp. 79–89, illus., diagrs., figs.

In investigations of lubricated sliding friction between two crossed cylinders, it is found that for hard, smooth surfaces the

High-nickel alloys, and chromium-nickel stainless steels, resist destructive effects of high temperatures in the Westinghouse "Yankee" engines that power the "Banshee" and "Phantom" jet fighters shown here. These twin-jets were built by McDonnell Aircraft Corporation, St. Louis 3, Mo. for the U. S. Navy. The turbo-jets are products of Westinghouse Electric Corp., Aviation Gas Turbine Division, South Philadelphia, Pa.

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friction force is a straight-line function of the applied load, although this line does not generally pass through the origin. The slope of this line defines a friction coefficient, designated as the incremental friction f_Δ, which is thought to have certain advantages in the study of nonfluid lubricated friction. It is obviously independent of the load. It is found to be independent of viscous fluid effects and, hence, permits investigation of nonfluid friction at reasonable speeds. In spite of being devoid of any viscous component, it is found in a great many cases to decrease with increasing speed, U, over at least part of the range, and this variation often appears to be a linear function of the logarithm of the speed. The curve of f_Δ vs. $\ln U$ seems to be characteristic of the chemical structure of the lubricant and of the rubbing surfaces. It is not contended that viscous effects are absent under the conditions of these experiments but simply that the value of f_Δ, which is not the total friction coefficient, does not, because of its method of determination, include such effects.

GEARS

Helical Gear Overlap for Smooth Operation. R. Howard. *Machine Design*, Vol. 21, No. 1, January, 1949, pp. 145, 146, diagr., chart.

A relative change is made in the angular position of individual sections of each tooth so that, although all sections are similar, successive portions of the tooth are engaged in passing through the contact zone. This tooth action provides for the gradual application and removal of the tooth load and results in a quieter and smoother transmission of power.

The Load Carrying Capacity of the Oil Film Between Gear Teeth. Ewen M'Ewen. *The Engineer*, Vol. 186, No. 4849, December 31, 1948, pp. 666, 667. 17 references.

SHAFTS & ROTATING DISCS

Strain Measurements on Rotating Parts. R. E. Gorton and R. W. Pratt. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint.* 24 pp., illus., figs. 20 references.

The development of apparatus and techniques for the measurement of the strains in rotating engine parts at the Pratt & Whitney Aircraft Division, United Aircraft Corporation. Measurement of the deflection of crankshafts during operation to verify the existence of uneven bearing loads and determination of the stresses in impeller blades at various frequency responses were the initial cases in which the measurement of vibration stresses by wire strain gages was undertaken. The technique was subsequently extended to the measurement of centrifugal stresses. Detailed description of the technique and apparatus includes: choice of gage, form of its grid, size, and manufacturing technique; location of axis of principal stress in test specimen; method of installing the gages; circuits; slip-ring assemblies, lead wires and connections; and instrumentation.

SPRINGS

Belleville Spring Design Charts. I. Leslie W. Jones. *Product Engineering*, Vol. 20, No. 1, January, 1949, pp. 161, 163, 165, 167, figs.

Maintenance (25)

Operation "Plumber"; Greasing the Wheels of the Berlin Air Lift. *Airports & Air Transportation*, Vol. 3, No. 67, January, 1949, pp. 209, 210. The Centralized Servicing Depot of the R.A.F. Transport Command at Honington.

Fire Protection for Airline Maintenance. S. G. Freck. *Aviation Maintenance & Operations*, Vol. 11, No. 2, January, 1949, pp. 36, 37, illus. The Kidde carbon-dioxide fire extinguisher system installed at the American Airlines Maintenance Depot, Tulsa, Okla.

Long Service for Trainers Means Constant Checking. *Canadian Aviation*, Vol. 22, No. 1, January, 1949, pp. 34, 36, diagrs.

Check That Spray Gun. J. W. Rocke and M. C. Anderson. *Aviation Maintenance & Operations*, Vol. 11, No. 2, January, 1949, pp. 34, 35, 50, 52, illus. The care, cleaning, inspection, and operation of spray guns.

New Small Plane Lubrication Method (Shell). *Airports and Air Carriers*, Vol. 15, No. 1, January, 1949, pp. 30, 31, illus.

British Maintenance Licensing. I. *The Aeroplane*, Vol. 75, No. 1960, December 31, 1948, pp. 822, 823, illus.

Management & Finance (45)

Aircraft Workers to Be in Big Demand in Spring. Karl Rannells. *Automotive Industries*, Vol. 100, No. 1, January 1, 1949, pp. 54, 84. U.S. Employment Service survey of present and anticipated employment levels in the aircraft industry and of the availability of skilled and unskilled aircraft workers.

What the Budget Means to Procurement. Robert Hotz. *Aviation Week*, Vol. 50, No. 3, January 17, 1949, pp. 12, 13.

Materials (8)

Determination of the Elastic Constants of Solids by Ultrasonic Methods. William C. Schneider and Charles J. Burton. *Journal of Applied Physics*, Vol. 20, No. 1, January, 1949, pp. 48–58, illus., figs. 10 references.

A rotating-plate technique in which ultrasonic transmission is plotted as a function of the angle of incidence of the waves allows determination of the velocities of dilatation and shear waves in the plate. From these data, Poisson's ratio and the mechanical moduli may be determined. The elastic constants of several metals and of a number of thermoplastic and thermosetting resins are in agreement with previous published data.

On the General Equations of Problems of Axial Symmetry in the Theory of Plasticity. P. S. Symonds. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 448–452. 4 references.

Previous solutions of axially symmetric problems in plasticity depend upon a fallacious assumption of "full plasticity." If, using the well-confirmed Mises flow condition, the general equations for axial symmetry form a system of hyperbolic type, the techniques of numerical integration, using the networks of characteristic curves that have been developed for supersonic flow problems, could be applied to these problems of plasticity. Actually, the equations are of the elliptic type, the "characteristics" being real only under the special condition that reduces the problem to one of plane strain.

A Mathematical Formulation of the General Continuous Deformation Problem. A. Gleyzal. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 429–437. 5 references.

The general stress-strain problem for continuous flow or continuous deformation of continuous media, such as viscous liquids or elastic or plastic solids. This method, an embedded coordinate system in which each particle carries with itself coordinates that vary continuously from particle to particle but which do not vary with time for a given particle as the body deforms, was used for the solution of the problem of the hollow cylinder under pressure or pure torsion and of a parallelepiped under pure shear. A tensor generalization of "natural strain" is found, and Young's modulus and Poisson's ratio for "finite strain" are derived. Infinitesimal strain and strain velocity are defined for continuous deformations and related to the deformation tensor.

METALS & ALLOYS

Apparatus for Tensile Testing at Sub-Zero Temperatures. E. J. Ripling and G. Tuer. *Product Engineering*, Vol. 20, No. 1, January, 1949, pp. 103–105, illus., diagrs., figs.

The coolant, usually isopentane, was held at the desired temperature by passing liquid nitrogen at a definite rate through a copper coil. Large insulating joints permitted holding the specimen at the desired temperature, while the main mass of the loading members remained at not much less than room temperature. Eccentricity of the loading and specimen axes was less than 0.002 in.

Direct-Reading Design Charts for 24S-T Aluminum-Alloy Flat Compression Panels Having Longitudinal Straight-Web Y-Section Stiffners. Norris F. Dow, Ralph E. Hubka, and William M. Roberts. *U.S., N.A.C.A., Technical Note No. 1777*, January, 1949. 36 pp., figs. 5 references. Charts for the determination of the stress and all the panel proportions that are required for a given intensity of loading with a given skin thickness and effective length.

Stress-Strain Rate Relations for Anisotropic Plastic Flow. John E. Dorn. *Journal of Applied Physics*, Vol. 20, No. 1, January, 1949, pp. 15–20, figs. 17 references.

A theory for correlating stress-strain rate pertinent to anisotropic sheet metals for the work-hardening range. The effects of orientation on the yield strength in simple tension and biaxial tension for various types of symmetry are evaluated. The theory

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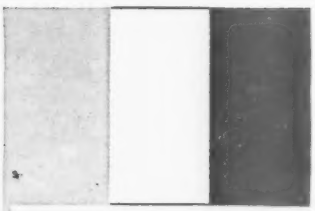

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appears to be approximately correct for mild steel plates that exhibit planar isotropy.

Surface Hardened Stainless Steels. Vincent T. Malcolm. *Product Engineering*, Vol. 20, No. 1, January, 1949, pp. 84–87, diagr., figs.

The Consumer Looks at Steel Specifications. Muir L. Frey. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint*, 18 pp., figs.

The Effect of Internal Stresses on Hardness. Paul Blain. *Sheet Metal Industries*, Vol. 26, No. 261, January, 1949, pp. 133, 136, fig.

Electronics in the Field of Non-Destructive Testing. R. Meakin. *Society of Instrument Technology, Transactions*, Vol. 1, No. 3, September, 1948, pp. 26–35, diagr., figs. Industrial application and operation of supersonic inspection equipment for flaw detection in block metals.

Surface Treatment and Finishing of Light Metals. I—Development of Light Metals, Their Applications and Finishes. S. Wernick and R. Pinner. *Sheet Metal Industries*, Vol. 25, No. 260, December, 1948, pp. 2463–2470, illus.

NONMETALLIC MATERIALS

Effect of Hyperbolic Notches on the Stress Distribution in a Wood Plate. C. Bassel Smith. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 452–456. 5 references.

An orthotropic plate with x- and y-axes parallel to the axes of symmetry. Forces are directed parallel to the x-axis and applied in the plane of the plate. They are assumed to act at great distances from the y-axis and in such a way that the traction over any cross section perpendicular to the x-axis is statically equivalent to a single force of magnitude P directed along the x-axis. The problem is treated as one of plane stress.

Drying and Conditioning Glued Joints. *U.S., Forest Products Laboratory, Madison, Wis., Report No. D475, Revised*, August, 1948. 7 pp., tables.

PROTECTIVE COATINGS

Ceramics for Molybdenum. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 31, 87, illus.

Preliminary results of N.A.C.A. and N.B.S. research indicate that molybdenum with an especially designed ceramic coating offers a promising heat-resistant combination. In air at 1,650°F., unprotected molybdenum sheet decreased 0.02 in. in thickness in ½ hour. There was no decrease for ceramic-coated molybdenum heated for 70 hours under the same conditions.

Ceramic Coated Metals for Aircraft Power Plant Applications. R. A. Jones. *Steel Processing*, Vol. 34, No. 12, December, 1948, pp. 649–651, illus.

A summary of the high-temperature and oxidation-resistant materials that have been developed in research sponsored by the Air Materiel Command. Both vitreous and unfired ceramic coatings, in addition to retarding oxidation and corrosion at high temperatures have been used to increase the strength and stiffness of the base material by virtue of their physical presence and by lowering the operating temperature. They also eliminate surface-stress raisers and reduce the magnitude of temperature gradients.

Protective Coatings; Characteristics and Applications of Chemical-Conversion Finishes. Joseph Mazia. *Machine Design*, Vol. 21, No. 1, January, 1949, pp. 110–114, illus.

Characteristics and applications of chemical-conversion finishes capable of protecting machine parts against premature failure. Used independently or to augment the properties of another type of finish, they form an integral part of the metal to which they are applied and, consequently, are strong, tractable, and resistant to chipping.

SANDWICH MATERIALS

The Effect of Veneer Thickness and Grain Direction on the Shear Strength of Plywood. C. B. Norris, Fred Werren, and P. F. McKinnon. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1801*, July, 1948. 36 pp., illus., figs. 8 references.

Panel, block, and tension shear tests were made. An approximate formula was derived for the shear strength of a plywood panel made from piles of uniform thickness of wood of the same species. Panels in which the directions of the grains of the veneers differed but which were made by the same techniques and

of the same number, thickness, and species of veneers will have similar shear properties as long as the panel is subjected to approximately pure shear. The test apparatus should apply the loads along the line of the edge of the part of the panel being tested. Checks introduced in cutting the veneer vary with species and with veneer thickness. The number of checks appears to be independent of the veneer thickness, but the depth of check increases with veneer thickness. Block shear tests gave shear values higher, and tensile shear tests gave values lower than those obtained from the panel shear tests.

Fatigue of Sandwich Constructions for Aircraft; Fiberglas-Honeycomb Core Material With Fiberglas-Laminate of Aluminum Facings, Tested in Shear. Fred Werren. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1559-C,* August, 1948. 8 pp., illus., fig.

Test data and corresponding S-N curves obtained from 43 shear-fatigue tests. At a ratio of minimum or maximum loading of 0.1, the fatigue strength at 30,000,000 cycles was approximately 42 per cent of the static strength.

Fatigue of Sandwich Constructions for Aircraft; Fiberglas-Laminate Face and End-Grain Balsa Core Sandwich Material Tested in Shear. Fred Werren. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1559-D,* September, 1948. 7 pp., figs.

Test data and corresponding S-N curves obtained from 14 shear-fatigue tests. At a ratio of minimum to maximum loading of 0.1, the fatigue strength at 30,000,000 cycles was approximately 58 per cent of the static strength.

Meteorology (30)

First Partial Report on the Artificial Production of Precipitation; Stratiform Clouds—Ohio, 1948. Richard D. Coons, R. C. Gentry, and Ross Gunn. *U.S., Weather Bureau, Research Paper No. 30,* August, 1948. 66 pp., illus., diagrs. 22 references.

Reports on 17 experiments to obtain basic data on cloud modification techniques, to assess the reality of artificial methods for the production of precipitation, and to determine their economic possibilities. Although, by dropping carbon-dioxide snow into a supercooled cloud, changes can be produced in the optical characteristics of the cloud, there is, as yet, little indication that such modification of clouds has any important bearing upon weather processes or any significant economic prospects.

AMC Cloud Physics Project Produces Artificial Precipitation. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest,* Vol. 14, No. 1, January 1, 1949, pp. 10–12. Coordination and verification of observations on precipitation and structural changes in clouds following seeding with dry ice.

A Method of Forecasting the Degree of Turbulence in Fronts and Line Squalls. R. M. Whiting. (*NavAer 50-1R-228.*) *U.S., Chief of Naval Operations, Aerology Flight Services Section, U.S. Navy Reprint,* November, 1948. 22 pp., figs.

Three hundred reports giving time, location, altitude, and degree of turbulence were obtained from aircraft flying through fronts or line squalls. Comparison with the synoptic situations showed that the degree of turbulence could be calculated with a 33 per cent expectancy of a 2° error from the impact factor; from the relative horizontal velocity of the air masses; from the vertical temperature gradient of the lowest 5,000-ft. stratum; and, at altitudes above 5,000 ft., from the maximum temperature difference, measured along constant pressure, between the air in cumulus clouds and the surrounding environment.

Causes of Thunderstorms of the Florida Peninsula. Horace R. Byers and Harriet R. Rodebush. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 275–280, figs. 9 references.

Experimental Verification of Entrainment of Air Into Cumulus. E. W. Barrett and H. Riehl. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 304–307, illus., figs. 7 references.

In order to observe rapidly changing micrometeorological weather phenomena, a reconnaissance airplane was equipped with two fine-wire thermocouples instead of conventional temperature-measuring instruments. One thermocouple was mounted on a strut so as to be completely exposed to the free flow of air and water; the other, in a housing that allowed free circulation of the air but deflected all water droplets from the wire so that the air temperature could be determined without the errors caused by contact of the thermocouple with large drops falling from a colder region higher in the cloud. An electronic dewpoint hygrometer supplied humidity data. The voltages developed by the instruments were measured and recorded successively on a Brown strip-chart potentiometer recorder.

Correspondence: The Growth of Cumuliform Clouds. F. H. Schmidt. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 308, 309, figs. 6 references.

Quantitative Analysis of Factors Influencing Pressure Change. Robert G. Fleagle. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 281–292, figs. 27 references.

Some New Mean Meridional Cross Sections Through the Atmosphere. Seymour L. Hess. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 293–300, figs. 6 references.

Quantitative Analysis of Vertical Structure in Precipitation. R. C. Langille. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 301–304, figs. 2 references.

Correspondence: Note on the Construction of Isokinetics in Cross Sections. W. Bleeker. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 309, 310. 4 references.

Vertical Eddy Flux of Heat in the Atmosphere. R. B. Montgomery. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 265–274. 34 references.

On the Formation of Typhoons. Herbert Riehl. *Journal of Meteorology,* Vol. 5, No. 6, December, 1948, pp. 247–264, figs. 21 references.

Military Aviation (24)

The Airlift to Berlin; An Eye-Witness Account of Operations and Supply on "Operation Vittles." W. D. Long. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest,* Vol. 14, No. 2, January 15, 1949, pp. 12–14, diagr.

New Crews for the Airlift. Esther H. Forbes. *U.S. Air Services,* Vol. 34, No. 1, January, 1949, pp. 9, 10, diagr.

Activity and Progress of Naval Aviation During 1948. *U.S. Air Services,* Vol. 34, No. 1, January, 1949, pp. 17–19, illus.

The Folly of Strategic Bombing; An Analysis of Maj. Gen. J. F. C. Fuller's New Book. Hoffman Nickerson. *Ordnance,* Vol. 33, No. 172, January-February, 1949, pp. 245–247, illus.

Naval Air Power; A Vital Weapon of Our National Defense Team. T. C. Lonnquest. *Ordnance,* Vol. 33, No. 172, January-February, 1949, pp. 265–267, illus.

Seventy Years Airborne; A History of (R.A.F.) No. 1 Fighter Squadron and its Antecedents. John Yoxall. *Flight,* Vol. 54, No. 2087, December 23, 1948, pp. 747–754, illus.

Exercise Sunrise. *The Aeroplane,* Vol. 75, No. 1958, December 17, 1948, pp. 751, 752. The British air-sea maneuvers conducted in the North Atlantic during December, 1948.

Dead Men Shoot Down No Planes. John B. B. Trussell, Jr. *Antiaircraft Journal,* Vol. 91, No. 6, November-December, 1948, pp. 27–30, diagr., fig. Analysis of the First Allied Airborne Army's invasion of northern Netherlands to show the value of fighter-aircraft action in reducing antiaircraft artillery positions and the security such positions require during airborne attack.

Co-Operation Airborne. *Aircraft and Airport,* Vol. 10, No. 12, December, 1948, pp. 16, 17, illus. Joint air school for Canada's three armed services.

Navigation (29)

Arctic Aerial Navigation; A Method for the Analysis of Complex Activities and its Application to the Job of the Arctic Aerial Navigator. J. M. Christensen. *Mechanical Engineering,* Vol. 71, No. 1, January, 1949, pp. 11–16, 22, illus., figs. 10 references.

Activity analyses were conducted during regular arctic flights of a Photo Reconnaissance Squadron and a Weather Reconnaissance Squadron from Ladd Field, Fairbanks, Alaska, to obtain data on which to base the redesign of present and the development of new navigation equipment and accommodations. An observer sampled the activities of the first and second navigator and the radar operator at successive 5-sec. intervals. Analysis of these samples provided data on the frequency and sequence of use of controls and equipment, the distribution of the crew members' time, minimum crew requirements, and minimum time for flights. The navigation work space was too small and too restrictive. One man cannot accomplish successfully the work of both the first and the second navigator. If, however, the radar operator were located in the navigator's compartment and the equipment layout redesigned, two men could accomplish the three functions. The estimated time requirements are tabulated for the combined

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functions of first and second navigator and for the combined functions of the navigators and the radar operator.

Navigation Training in the Royal Canadian Air Force. G. F. Jacobsen. *Navigation*, Vol. 1, No. 12, December, 1948, pp. 256–259.

Letters to the Editor: Preliminary Study of a Physical Basis of Bird Navigation. William C. Schumacher. *Journal of Applied Physics*, Vol. 20, No. 1, January, 1949, p. 123.

Ordnance & Armament (22)

Air Progress: Development of Gun Turrets. Douglas Rolfe. *Air Trails*, Vol. 31, No. 5, February, 1949, pp. 28, 29, diagrs. Cutaway drawings of eight British and American designs.

Organizations & Societies (46)

I.A.S. Seventeenth Annual Meeting; Technical Sessions. I. Alexander Klemin. *Aeronautical Engineering Review*, Vol. 8, No. 3, March, 1949, pp. 27–41, illus., figs.

Correlation and summaries of papers presented at the technical sessions during the first 2 days of the I.A.S. Seventeenth Annual Meeting in New York, January 24 and 25, 1949. These sessions were on Rotating Wing Aircraft, Aircraft Design, Instruments, Flight Propulsion, Cloud Physics, Upper Atmosphere, and Transonic and Supersonic Aerodynamics.

International Civil Aviation Organization (ICAO). William K. Hitchcock. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 458–461.

International Air Transport Association (IATA)—Fourth Annual General Meeting. *Journal of Air Law and Commerce*, Vol. 15, No. 4, Autumn, 1948, pp. 462–465.

Photography (26)

Recent Results in Spark Cinematography. H. Schardin and W. Struth. (*Zeitschrift für Technische Physik*, Vol. 18, No. 11, November, 1937.) *U.S., Navy, The David Taylor Model Basin, Translation No. 107*, December, 1942. 10 pp., figs. 5 references. Phases of high-velocity projectile movement against mass inertia of wires, armor plate, glass, plastics, screens, and bodies of water are described by film strips of 24 successive images at frequencies up to several millions per second.

New Precision Camera Calibrator. *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 33, No. 1, January, 1949, pp. 8–10, illus. 4 references.

An instrument for the calibration of precision airplane mapping cameras. Only one negative is used to determine the distortion characteristics of a lens-cone combination, the equivalent focal length of the mounted lens, the magnitude of the prism effect, and the effects of tangential distortion.

Power Plants

Some Aspects of Power Plant Development. E. W. Still. *Royal Aeronautical Society, Journal*, Vol. 52, No. 456, December, 1948, pp. 767–793, Discussion, pp. 793–798, illus., diagrs., figs.

The painstaking, thorough research and development expended on aircraft power plants have not only yielded increased engine performance but have also contributed directly to passenger comfort and safety. High-efficiency radiators and oil coolers that automatically vary their rate of cooling with the engine temperature make operation under extremes of temperature possible and thereby increase the reliability of engines. In addition to the greater maximum flight speed that is obtained by utilizing exhaust thrust, exhaust systems are modified to hide the exhaust flame, which might cause anxiety to the passengers. Fuel and lubricant lines and fittings resistant to high temperatures and engine vibration reduce the fire hazard. The fire indicators and extinguishing systems that are incorporated in the power plant have demonstrated their efficiency in engine fire tests under simulated flight conditions. Passenger discomfort from propeller and engine-exhaust noise has been minimized. Extensive investigation on the sources, frequency distribution, and elimination of aircraft noise and vibration has given information that enable aircraft to be constructed which equal any other means of transportation in passenger comfort.

JET & TURBINE (5)

Trends in the Application and Maintenance of Turbojet Engines. R. P. Kroon and R. B. Rogers. *Aeronautical Engineering Review*, Vol. 8, No. 3, March, 1949, pp. 42–47, 77, illus., figs.

More efficient compressors, combustion chambers, turbines, and nozzles have reduced fuel consumption of jet engines 30 per cent, and higher pressure ratios, multiple compressors, and multiple turbines have improved the overall efficiency of the power plant. Extended useful range and maximum power are made possible by structures and materials developed for high operating temperatures and pressures. The multiplication of accessories to provide power for air-frame and engine supplementary services tends to nullify the advantage of the power plant's inherent simplicity and introduce the most frequent causes of engine trouble. Nevertheless, the time between overhauls has been reduced to 150 hours, and the pay-load mileage of a 300–400 m.p.h. turbojet compares with that of a reciprocating engine. The difference between operating conditions at subsonic speeds and near-sonic speeds may dictate two distinct types of engines in order to fulfill the increasing performance and operational requirement. The trend toward complexity these requirements cause may be compensated for either by simpler, more reliable, higher quality accessories or by the adoption of separate gear boxes and power sources instead of more power pads, by the combination of accessory functions or by the divorce of auxiliary services from the turbojet power plant.

Navy Tests Jet Engine (FJ-1 Fury) Danger Area. *U.S., Central Air Documents Office (Navy-Air Force, Technical Data Digest*, Vol. 14, No. 1, January 1, 1949, p. 5. The approach of a human into a jet-intake zone. Air velocity, less on the sides on the intake, diminishes rapidly from 38 knots at 2 ft. to 5 knots at 4 ft.

New Ramjet Test Stand Operating. *Aviation Week*, Vol. 49, No. 24, December 13, 1948, p. 26, diagr.

Flight conditions at altitudes from sea level to 60,000 ft. can be simulated on the ram-jet test stand at the Applied Physics Laboratory of The Johns Hopkins University by control of the air supplied either from pressure tanks or from the atmosphere. A 60-ft. cooling tower conducts exhaust gases from the test unit to the atmosphere.

Packard's Jet-Engine Test Facilities. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 32, 33, 86, 87, illus.

Checking Jet Blades. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 36, 37, illus.

The automatic Pant-O-Scriber Blade Checker, manufactured by Engineering Specialties Division, Buffalo, N.Y., completely checks, in less than 1 min., three sections of finished turbine blades for contour twist, thickness, width, and other specifications. An inspection record of each blade is obtained on a coated glass plate.

Blade-Root Grinding. *Aircraft Production*, Vol. 11, No. 123, January, 1949, pp. 17–19, illus., figs. The Matrix Type 43 special-purpose machine developed by the Coventry Gage & Tool Co., Ltd., for the Bristol Aeroplane Co., Ltd., for grinding fir-tree roots of gas-turbine rotor blades.

Teeth for the Jets. R. L. Wiseman. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 40, 41, 90, 91, illus.

Small parts casting of Vitallium, a cobalt-chromium-molybdenum alloy with a melting point of approximately 2,500°F., using dental process. Development of Vitallium and the Microcast production procedures are credited to Austenal Laboratories, Inc.

The Boeing 200 H.P. Gas Turbine (Model 502). S. D. Hage. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint.* 7 pp., illus., diagrs.

Starter Developed for Turbine Engines. Robert McLarren. *Aviation Week*, Vol. 49, No. 26, December 27, 1948, pp. 27, 28, illus., diagr.

AiResearch Manufacturing Company's self-contained self-starting, high-speed pneumatic unit for turbojet and turboprop aircraft. Operation is by air bled from a small, lightweight, centripetal-type turbo installation.

Self-Starter for Jet, Turboprop Engines Developed by Navy (AiResearch Pneumatic Starter). *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 14, No. 2, January 15, 1949, pp. 10, 11, diagr.

Centrifugal or Axial? *Aircraft and Airport*, Vol. 10, No. 12, December, 1948, pp. 12–14, illus.

German Gas Turbines—Appendix to Combined B.I.O.S. Report. *Flight*, Vol. 55, No. 2089, January 6, 1949, p. 26. Table of specifications and performance of 15 models.

Progress in British Aircraft and Engines. I. S. E. Veale. *Western Flying*, Vol. 29, No. 1, January, 1949, pp. 14, 15.

RECIPROCATING (6)

Post-War Development of the Reciprocating Aircraft Engine F. J. Wiegand and E. H. Olson. *S.A.E. Annual Meeting, Detroit, January, 1948, Preprint.* 9 pp., illus., figs. Changes in the materials, production and testing methods, and design of the cylinder-head finning, valves, valve seats, piston, connecting rod boss, crankshaft, crankcase, and ignition system of the Wright C18 aircraft engine.

How Powerplant Installation Troubles Hampered Airline Operation—1937–47. John W. Baird. *SAE Journal*, Vol. 57, No. 1, January, 1949, pp. 62–67, figs. (Extended summary of a paper: Survey of Powerplant Installation Troubles in Scheduled Air Carrier Operations.)

Engine Conditioning. III—Practical Engine Maintenance. *Aviation Maintenance & Operations*, Vol. 11, No. 2, January, 1949, pp. 29, 55, 58,

ROCKET (4)

The Atomic Rocket. II. L. R. Shepherd and A. V. Cleaver. *British Interplanetary Society, Journal*, Vol. 7, No. 6, November, 1948, pp. 234–241, figs. 1 reference.

The temperature at the beginning of expansion of a rocket propellant that utilizes the energy of atomic fission should be as high as the strength and cooling capacity of the rocket will withstand. The molecular weight of the propellant should be at a minimum. Operating temperatures sufficiently high to dissociate complex molecules would allow dense compounds with good storage and handling characteristics to be used efficiently. At working temperatures between 3,000° and 5,000°K., hydrogen, or one of its compounds, in either normal or isotopic forms, could produce calculated effective molecular weights between 1.5 and 8, so that exhaust velocities would be from 5 to 15 km. per sec.

Major Developments in the Field of Rocket Engines. K. F. Mundt. *Western Flying*, Vol. 29, No. 1, January, 1949, pp. 11, 15, 16.

Production (36)

Equal Emphasis on Producibility Adopted for New Warplane Designs. Robert McLarren. *Automotive Industries*, Vol. 100, No. 1, January 1, 1949, pp. 30, 31, 58.

The Air Force's 20 per cent producibility factor in evaluating new warplane design. Requirements include simplifications, uniformity and standardization of parts, and ease of fabrication to provide low-volume production using readily expandable high-volume design and tooling.

The Design of Aircraft Structures for "Mass Production." O. A. Wheelon. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint.* 12 pp., illus., figs.

Cost criteria to determine the suitability of design for moderate production. Design determines the basic cost and the degree of departure from it. In moderate production, departures are multiples of the basic cost. In comparing moderate with high production, the costs of raw material and purchased parts are seen to rise and those of engineering and tooling to decrease, while those of labor retain a consistent importance. Design influences this value in the man-hours required by intermediate management levels for learning and effecting progressive solutions, corrections, and eliminations. Generally, this cost of departure can be modified through considering a philosophy of producibility: staying within manufacturing limitations, being in step with the rest of the organizations, and employing only "sure-fire" design practices.

Bristol Brabazon; Structure of the Outer Wing: Spar Manufacture: Outer-Wing Assembly in Main Fixture. *Aircraft Production*, Vol. 11, No. 123, January, 1949, pp. 20–28, illus., diagrs.

Building a New Type. G. R. Edwards. *Aircraft Production*, Vol. 11, No. 123, January, 1949, pp. 12–16, figs. (Extended summary of a paper: Problems in the Development of a New Aeroplane.) The planning of the general production program and the

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coordination and organization of the drafting, experimental, and lofting departments during the production of a modified aircraft or the prototype for a new design.

How Convair Produces B-36, World's Largest Bomber. *Aviation Week*, Vol. 50, No. 3, January 17, 1949, pp. 34, 35, 37, illus., diagrs. Layout of the stations on the assembly line of Consolidated Vultee Aircraft Corportion at Ft. Worth, Tex. Illustrations show successive stages in the assembly of the B-36 bomber.

Tensioning Skin-Panels; Mechanical and Thermal Methods Adopted by Hawker Aircraft, Ltd. *Aircraft Production*, Vol. 11, No. 123, January, 1949, pp. 9–11, illus.

Cost Cutting Chance Laws Can Control Design Tolerances. Dorian Shainin. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint.* 14 pp., figs. 3 references.

Control charts used in the statistical quality-control method developed by W. A. Shewhart give the average dimension of the product of manufacturing operation and the range of variation of this value in the samples from which the average was obtained. They enabled the operator to detect any variation that is not inherent in the materials or the process, and, by keeping the entire output within the permissible limits of variation, they reduce rejects to a neglegible quantity. By applying the same analysis to the components of an assembly, tolerance limits can be modified to conform to the actual range of variation of the components' dimensions. A nomogram is given by which the units of combination tolerance in two-part assembly can be determined from the units of tolerance in each of the components. A graph gives the same information for assemblies of two to ten parts, when the tolerance of all the elements may be considered identical.

Batch-Production Control. E. J. Napier. *Aircraft Production*, Vol. 11, No. 123, January, 1949, pp. 3–8, illus., figs.

Details of the production control system and forms used by Electro-Hydraulics, Ltd., for production planning, material control, machine allocation, and machine loading. The machine loading plan shows the progress of the various contracts in general terms. From it future loading and plant commitments may be predicted.

Plastic Tooling Proves Its Worth. Robert McLarren. *Aviation Week*, Vol. 50, No. 2, January 10, 1949, pp. 20, 21, illus.

By forming resin-impregnated Fiberglas cloth over conventional molds and curing it under heat and pressure, Republic Aviation Corporation fabricates aircraft tooling that has better dimensional stability and is more adaptable to the forming of complex shapes than the steel tooling in common use. The process reduces toolmaking time 60 per cent, does not require skilled tool makers, and gives a product that can easily be reworked and repaired.

Tool Planning Pares Production Expense. John S. Mason. *The Martin Star*, December, 1948, pp. 12, 13, illus., figs.

Costs Cut With Portable Jig Bore. *Aviation Week*, Vol. 49, No. 26, December 27, 1948, p. 25, illus.

Consolidated Vultee Aircraft Corporation expedites precision work on forgings or castings while they are assembled on major aircraft components. A conventional pneumatic power tool turns the boring bar, and a universal drive permits offset.

Fly-Press Tooling. *Aircraft Production*, Vol. 11, No. 123, January, 1949, pp. 31, 32, diagrs. Standard tools designed by A. V. Roe and Co., Ltd., for light punching, blanking, and forming on a fly press.

Aluminum Alloy Pressure Moldings. James L. Erickson. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 46, 47, 86, illus., tables.

Castings possessing mechanical properties equal to certain light-metal alloy forgings and comparable with alloyed cast iron and malleable iron are suited for applications where the part is to be subjected to relatively high-tensile, impact, or fatigue stresses. They are cast with the aid of high-speed automatic cold-chamber casting machines and require little or no machining prior to assembly. The specification was issued by the A.A.F., July 1, 1942, and has been adopted in substantially the same form by the S.A.E. and the A.S.T.M. in order to eliminate inconsistent mechanical performance and to improve the relatively poor overall mechanical properties of die castings.

Aluminum Cast in Plaster. E. A. Canning. *SAE Journal*, Vol. 57, No. 1, January, 1949, pp. 60, 61, illus. (Summary of a paper: Relation of the Antioch Process to the Foundary.)

Centreless Grinding; Production of Workpieces With "Difficult" End Profiles. *Aircraft Production*, Vol. 11, No. 123, January, 1949, p. 11, illus., diagrs.

Recent Developments in the Pressure Welding of Light Alloys. R. F. Tylecote. *Sheet Metal Industries*, Vol. 26, No. 261, January, 1949, pp. 161–168, figs. 7 references. Cleaning and preparation of the surfaces, required temperature and loads, and the microstructure and strength characteristics of aluminum-alloy pressure welds.

Contact Arc-Welding; A Description of a New Technique. P. C. van der Willigen. *Sheet Metal Industries*, Vol. 26, No. 261, January, 1949, pp. 155–160, 168, illus., figs.

Electrode coatings with sufficient iron content to make semiconductors facilitate starting, concentrate the arc, ensure constant arc length, and increase root penetration and metal deposition. The use of a touch-welding technique simplifies welding in inaccessible places and produces more uniform welds.

The Application of Resistance Welding to Sheet Metal Practice. L. H. Park. *Sheet Metal Industries*, Vol. 25, No. 260, December, 1948, pp. 2487–2494, 2496, 2498, illus., figs.

Characteristics of the Arc in "Heliarc" Welding. H. T. Herbst. *Electrical Engineering*, Vol. 68, No. 1, pp. 30–33, illus., diagrs.

Two properties of an electric arc in an atmosphere of inert gas are: its cleaning action when d.c. reverse polarity is used on oxide-forming metals and the resistance to current flow, which is considerably higher when the electrode is positive than when it is negative. In welding with a.c. there is a combination of the characteristics peculiar to straight and reverse polarity.

Some Fundamental Principles of Argon Arc-Welding. *Sheet Metal Industries*, Vol. 26, No. 261, January, 1949, pp. 169, 170, 174, diagrs.

Production Processes, Their Influence on Design. XL—Projection Welding. Roger W. Bolz. *Machine Design*, Vol. 21, No. 1, January, 1949, pp. 121–126, illus., figs.

Major Factors in Selecting Materials Handling Equipment for Aircraft Plant Operation. G. E. Musk and J. Nelson. *Automotive Industries*, Vol. 100, No. 1, January 1, 1949, pp. 40, 41, 74, illus. Detailed discussion by engineers of Northrop Aircraft, Inc., of factors and problems as they appear to the aircraft plant engineer.

Fabric Finish by Spray-Gun. *Aircraft Production*, Vol. 11, No. 123, January, 1949, p. 28. The Spraytex method for producing a fabric-like surface finish on aircraft interiors. Finely ground or cut rayon stable fibers are sprayed with a Miser fiber-gun on a surface that has previously been coated with a resin adhesive.

Shot Peening; A Survey of Modern Methods and Applications. G. T. Colegate. *Sheet Metal Industries*, Vol. 26, No. 261, January, 1949, pp. 141–148, 152, figs. 12 references.

Propellers (11)

The Future of the Propeller. A Russell Trotman. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 18, 19, 85, illus., figs.

The economy of the turboprop-powered aircraft will determine its wider range of application, wider than that of the turbojet, through subsonic, sonic, and lower supersonic speeds. Selection of a slipstream area most efficient within the aircraft's special limitations and a favorable ratio between its velocity and that of the craft are elements of such a preference. Combined with the power facilities of the gas turbine and newly evolved blade configurations, these advantages can be utilized to maintain efficient operation into the higher speed levels.

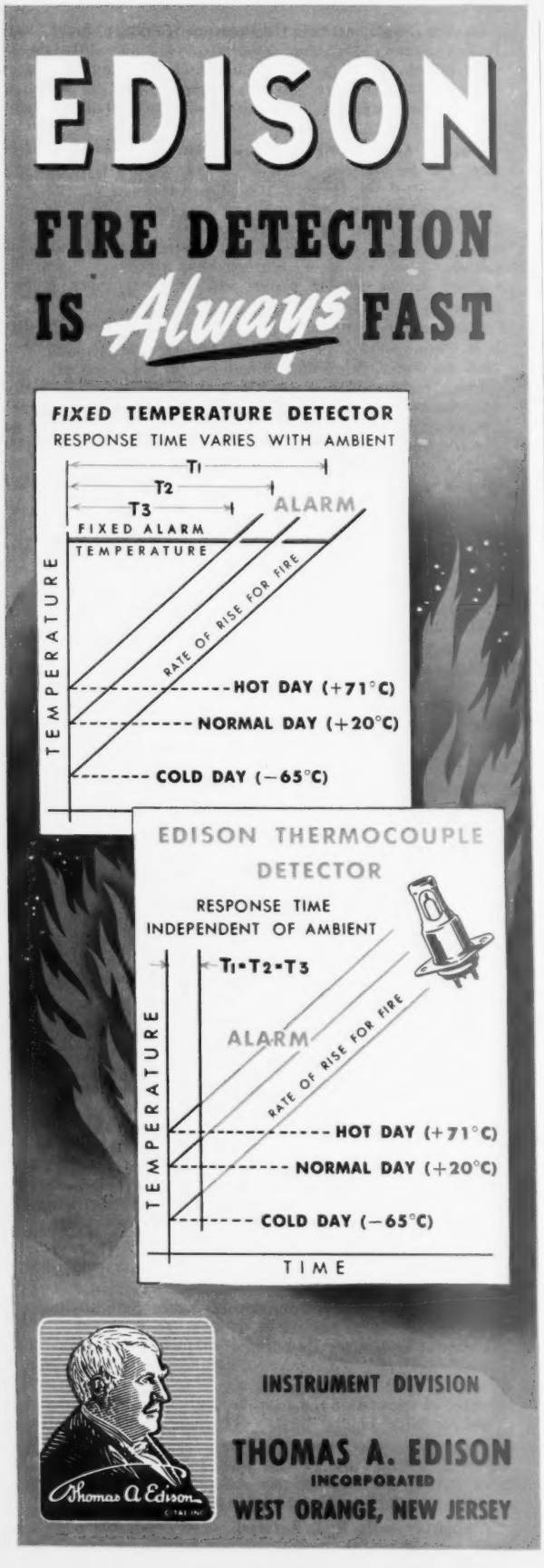
Windmills or Jets? *Flight*, Vol. 54, No. 2088, December 30, 1948, pp. 786, 787, illus., fig. Current trends in propeller design and operation.

Self-Contained Oil Control Assembly for Propellers. *Aviation Week*, Vol. 50, No. 2, January 10, 1949, p. 30, illus.

A control system for Hamilton Hydromatic propellers. The hydraulic system is self-contained, and fluid lighter than engine oil may be used. The complete accessory unit and oil tank is mounted at the rear of the propeller hub and can be used for propellers with blades larger and wider than conventional blades.

Reversible Props Brake Plane in Dive. Irving Stone. *Aviation Week*, Vol. 49, No. 26, December 27, 1948, pp. 22, 25, illus. Procedure used in 40° descent of C-54 from 15,000 ft.

In-Flight Propeller Pitch Reversal. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 24, 91, illus. (Cf. preceding abstract.)



Reference Literature (47)

HISTORY

One Era Ends and We are Only at the Beginning; A Quick Glance at Events Since 1903. Lawrence D. Bell. *U.S. Air Services*, Vol. 34, No. 1, January, 1949, pp. 13–16, illus.

Research Facilities (50)

French Aeronautical Research. I. G. Bruner. *The Aeroplane*, Vol. 75, No. 1960, December 31, 1948, pp. 818, 819, illus., diagrs.

The grouping of French aeronautical research facilities into a single organization, L'Office National d'Expériences et de Recherches Aéronautiques, was made in May, 1946. Inventory of available facilities, a program for immediate research, and the investigation of future needs are parts of a 5-year plan.

Research First; The Laboratory Sets the Pace for Industrial-Military Mobilization. A. R. Glancy. *Ordnance*, Vol. 33, No. 172, January-February, 1949, pp. 268–270, illus.

Wartime Aeronautical Research & Development in Germany. III—The Aerodynamic Research Establishment at Göttingen (Continued). J. J. Green, R. D. Hiscocks, and J. L. Orr. *The Engineering Journal*, Vol. 31, No. 12, December, 1948, pp. 627–632, diagrs.

Research programs and equipment of the Institutes for Unsteady Fluid Motion, Low-Temperature Research, and Coal Utilization for Gas Turbines of the Göttingen establishment and Kaiser Wilhelm Institute for Flow Mechanics. Condensed from a report submitted by an inspection team of the National Research Council, Canada.

Rotating Wing Aircraft (34)

Today's Picture in Helicopters. R. H. Prewitt. *S.A.E. Annual Meeting, Detroit, January 10–14, 1949, Preprint.* 6 pp., figs.

The potential field of application of the helicopter; trends in operating cost; and a comparison of the performance characteristics, designs, and the inherent advantages and disadvantages of the single main-rotor helicopter with torque-compensating tail rotor, the synchropter (side-by-side intermeshing rotors), the coaxial-rotor helicopter, configurations incorporating two rotors disposed side-by-side and two rotors disposed fore and aft, machines with a single jet-propelled rotor, and the convertaplane.

The Helicopter's Role in the Armed Forces. In the Army Field Forces. Doyle O. Hickey. **In the U.S. Navy.** J. D. Price. **In the U.S. Air Force.** A. T. Culbertson. **In the U.S. Coast Guard.** J. F. Farley. **In the U.S. Marine Corps.** William J. Wallace. *American Helicopter*, Vol. 13, No. 2, January, 1949, pp. 13–23, illus.

Landing a Helicopter, Engine-Off. Alexander Klemin. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 50, 51, 70, figs. The technique of landing from a high-speed approach glide with a subsequent float; the chance of a poor landing is remote.

Problems of Crop Spraying. Elmer Schlesinger. *American Helicopter*, Vol. 13, No. 1, December, 1948, pp. 6, 7, 21–23, illus. Agricultural operations, analysis of revenue, sales-promotion methods, operating techniques, and description of helicopter spraying equipment of Helicopter Services of California. It was possible to apply weed-eradication chemicals with only 5 or 6 gal. of water per acre because the down-wash of the rotor directed the concentrated solution into the weeds and distributed the spray evenly across the swath.

ATC for Hiller 360. *Aero Digest*, Vol. 58, No. 1, January, 1949, p. 52, illus. Simple overhead linkage of control stick to a servocontrol rotor eliminates the cables, pulleys, and levers found in conventional helicopters.

Helicopters for Inter-City Service. E. Colston Shepherd. *Indian Skyways*, Vol. 2, No. 11, November, 1948, pp. 45–47.

The Air Horse Airborne (Cierva W.11 17,500-lb. Helicopter). *The Aeroplane*, Vol. 75, No. 1958, December 17, 1948, pp. 749, 750, illus., diagr.

Sciences, General (33)

MATHEMATICS

Homogeneous Harmonic Functions. H. Poritsky. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 379–388, figs. 4 references.

Solutions of Laplace's equation. The case of $n = 0$ with proper change of variables finds an important application in supersonic conical flows. By introducing isothermal coordinates along the unit sphere, solutions may be expressed in terms of analytic functions of a single complex variable. For positive or negative n, the solutions may be expressed similarly in terms of analytic functions of a complex variable by either one of two methods: by differentiating the solutions for $n = 0$ with respect to x, y, z and using inversion or, for positive integer n, by utilizing Euler's identity for homogeneous functions of degree n. The case $n = 1$, also of interest from the point of view of conical flows, is discussed at length.

A Modified Method of Iteration of the Picard Type in the Solution of Differential Equations. Gwoh-Fan Djang. *Franklin Institute, Journal*, Vol. 246, No. 6, December, 1948, pp. 453–457. 4 references. Advantages are the method's faster convergence of successive approximations and its direct use in cases where boundary conditions are spread or are concentrated at a single point.

MECHANICS—VIBRATION

A New Method of Vibration Measurement for the Frequency Range 20 to 20,000 Cps. Frank Massa. *Instruments*, Vol. 21, No. 11, November, 1948, pp. 1012–1014, illus., figs.

Linearity, unidirectional sensitivity, freedom from resonance, and uniform phase shift between the mechanical input and the electrical output of the system are obtained in an accelerometer unit by a stiffness controlled to beyond 20 kc. and by an electromechanical system with a single degree of freedom. Ammonium di-hydrogen phosphate crystal plates are mounted in a housing and so arranged that a stress is imparted along the piezoelectrically sensitive axis of the plates only in proportion to the component of mechanical vibration that exists along the normal geometric axis of the housing.

Stress Analysis & Structures (7)

Theory of Buckling of Frameworks. Thomas C. Kavanagh. *New York University, College of Engineering, Doctoral Thesis*, April 1, 1948. 63 pp., figs. 164 references. Column Research Council, The Engineering Foundation, New York.

An abstract of a survey of framework-stability theory which was made during a study of truss stability analysis and design by approximation. The fundamental relationships that can be derived from the differential equation of a single axially loaded bar are extended to groups of bars in order to form a background for an investigation of the stability of such groups. A stability analysis of trusses with fixed joints or of any other type of framework is shown to be an analysis of an indeterminate structure modified for the presence of axial loads. All theories of stability analysis are stated and are developed from a common base to show their interrelation.

Comparison of the Structural Efficiency of Panels Having Straight-Web Y-Section Stiffeners. Norris F. Dow and William A. Hickman. *U.S., N.A.C.A., Technical Note No. 1787*, January, 1949. 20 pp., illus., figs. 5 references.

In the high-stress region, in which failure is at least in part associated with local buckling, panels having curved-web Y-section stiffeners have higher structural efficiencies than panels having straight web Y-section stiffeners. These higher structural efficiencies are evidenced by higher average stresses at failure, smaller stiffener heights, or wider average spacing of rivet lines, in various combinations, according to the design requirements.

Pressurized-Cabin Elementary Frame Analysis. I. William F. Vogel. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 62, 63, 88, 90, figs. 5 references.

Analysis of a simple pressurized frame by the minimum strain-energy method. Castigliano's deflection and minimum energy theorem and the Maxwell-Mohr method are fundamentally similar strain-energy methods. Equal results should be expected. Castigliano's method is perhaps a bit easier to use in more complex cases where difficulty may be encountered in setting up the problem on the Maxwell-Mohr basis.

On the Plastic Bending of Circular Plates Under Uniform Transverse Loads. D. Trifan. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 417–427, figs. 13 references.

Although the theories of plastic flow and plastic deformation are founded on different hypotheses, their predictions for circular plates under uniform loads are identical for all practical purposes. Both plastic theories, however, give a deviation from the elastic solution which ranges to better than 10 per cent, depending on the load and the points in the material under consideration.

The Determination of Stresses in Plastic Regions in Problems of Plane Flow. P. S. Symonds, *Journal of Applied Physics*, Vol. 20, No. 1, January, 1949, pp. 106–112, figs. 9 references.

This simple numerical-graphical method for the calculation of stresses in plastic zones adjacent to boundaries of arbitrary shape is applicable to problems of plane plastic flow in ideally plastic materials. The method is applied to determine the stresses in plastic zones near elliptic free boundaries, and the yield load of a tensile containing elliptic notches is obtained for a series of notches of varying sharpness.

The Optical Equations of Three-Dimensional Photoelasticity. Raymond D. Mindlin and Lawrence E. Goodman. *Journal of Applied Physics*, Vol. 20, No. 1, January, 1949, pp. 89—95. 8 references.

Propagation of light in a heterogeneous aeolotropic medium Passage from Maxwell's electromagnetic equations for a few special cases of the combined problem of the homogeneous aeolotropic medium and the heterogeneous isotropic medium to F. Newmann's approximate treatment, which is derived from purely kinematical considerations, discloses the nature and order of magnitude of the necessary approximation. A pair of equations opens the way to a variety of a new solutions in closed form and reveals the essential parameter on which the optical phenomena depend.

Loads on Wing and Tail Surfaces of an Aeroplane Due to a Sinusoidal Gust Wave. A. I. van de Vooren. *Netherlands, National Luchtvaartlaboratorium, Amsterdam, Rapport Nr. F.33*, October 6, 1948. 20 pp., figs. 2 references. (In English.)

The calculation of gust-load coefficients for the case of a single sinusoidal gust wave takes into account the rotation of the airplane about its lateral axis and the aerodynamic lag. The length of the gust wave and two other parameters with predominant influence on the resulting loads are varied. Graphs show comparison of the results with those pertaining to persisting gusts.

Aircraft Weight and Balance. I. M. C. Anderson and J. W. Rocke. *Aero Digest*, Vol. 58, No. 1, January, 1949, pp. 42–44, 92, 94, figs. Flight difficulties attending improper loading, procedures for correct loading, terms and their definitions, weights, datum line, center-of-gravity, moments, classes of equipment, and aircraft specifications.

Bonded Resistance Wire Gages for Strain Measurements. Arthur C. Ruge. *Product Engineering*, Vol. 20, No. 1, January, 1949, pp. 116, 117, diagrs. Diagrams of ten types of gages for determining uniaxial and biaxial stresses. Factors determining the choice are gage length, gage size, and gage resistance.

Thermodynamics (18)

Some Recent Developments in Heat Transfer: Analytical Methods; Boiling Liquids; Heat Transfer for Compressible Flow of Air. W. H. McAdams. *Purdue University, Engineering Experiment Station, Engineering Bulletin*, Vol. 32, No. 2 (*Research Series No. 104*), March, 1948. 54 pp., illus., diagrs., figs. 71 references.

A review of developments since 1942. Analytical methods have been developed for only specific problems in transient and steady heat transfer. Numerical methods, such as the increment method and relaxation procedures, can be applied more generally in both one- and two-dimensional problems. The curve of heat-flux-density variation with temperature difference between a submerged surface and a boiling liquid is divided into four zones: natural convection to the liquid with evaporation at the surface of the liquid; nucleate boiling; unstable partial-vapor-bound boiling; and fully-vapor-bound or film boiling. The peak heat-flux density at the critical temperature differential of organic liquids is correlated for reduced pressures. The Martinelli analogy between heat transfer and momentum, which differs from von Kármán's by not neglecting molecular thermal diffusion, gives markedly

higher predictions at extremely low Prandtl moduli. Charts have been developed for the relations betwen mean temperature difference, heating effectiveness, and heat-capacity ratio of a heat exchanger from which the required surface or, for an existing exchanger, the outlet temperature can be predicted. The basic equations for fluid flow in tubes are applied to the heating of air with compressible flow in a tube. The McAdams, Nicolai, and Keenan apparatus for producing subsonic compressible flow was used to determine recovery factors and coefficients of heat transfer. A recovery factor was found necessary for temperature probes at moderate temperature differences with Mach Numbers 0.4 to 1.0. An empirical equation is given for heat transfer at Reynolds Numbers 10,000 to 400,000.

Heat Transfer in Sweat-Cooled Porous Metals. Sidney Weinbaum and H. L. Wheeler, Jr. *Journal of Applied Physics*, Vol. 20, No. 1, January, 1949, pp. 113–122, figs. 7 references. Analysis of the transfer and derivation of formulas showing temperature distributions along the length of a sweat-cooled bar and across a sweat-cooled hollow cylinder.

A Problem of the Temperature Distribution in a Moving Medium. A. E. Benfield. *Quarterly of Applied Mathematics*, Vol. 6, No. 4, January, 1949, pp. 439–443, figs. 8 references.

A Method for the Experimental Investigation of the Hilsch Tube. O. B. Finamore. *Cornell Aeronautical Laboratory, Inc., Report No. HF-566-A-1*, August 30, 1948. 9 pp., figs. 5 references.

A 2.5-in. pipe and a tangential nozzle with a 1.25-in. orifice were used to form a Hilsch tube. Measurements of temperature, pressure, and flow characteristics in the entrance chamber showed that an air-supply pressure of 27 lbs. per sq.in. atmosphere gave a temperature differential sufficient for the investigation of the screwlike flow phenomena observed by Hilsch. A larger model could be constructed to accommodate the required instrumentation.

Water-Borne Aircraft (21)

Comparison of Over-All Impact Loads Obtained During Seaplane Landing Tests With Loads Predicted by Hydrodynamic Theory. Margaret F. Steiner. *U.S., N.A.C.A., Technical Note No. 1781*, January, 1949. 47 pp., illus., diagrs., figs. 5 references.

The loads and displacements measured during landings of a full-scale flying boat in smooth water, in which little rotation in pitch occurred and which involved only the V-shape portion of the forebody, agreed well with computed general hydrodynamic impact theory. When the forebody chine was immersed in the free water surface at the time of peak load, the measured peak loads were about 60 per cent higher than the computed peak loads. When the nonprismatic-bow region was involved before peak load was reached, the experimental maximum load was less than the computed load. Downward rotation caused reduction in load during the early part of an impact but no corresponding reduction in the maximum load. The consequent vertical velocity at which the chine flare was immersed resulted in high local pressures in the region of transverse curvature which exceeded the computed maximum loads.

Hydrodynamic Impact Loads in Smooth Water for a Prismatic Float Having an Angle of Dead Rise of 40°. Philip M. Edge, Jr. *U.S., N.A.C.A., Technical Note No. 1775*, January, 1949. 22 pp., illus., figs. 7 references.

Tests were made at the Langley impact basin in smooth water at fixed trims of 3°, 6°, 9°, and 12° for a range of flight-path angles of approximately 2° to 22°. The experimental value of the deadrise function decreased 44 per cent as the angle of dead rise increased from 22½° to 40°. Data agree well with theoretical values.

Effect of Hull Length-Beam Ratio on the Hydrodynamic Characteristics of Flying Boats in Waves. Arthur W. Carter. *U.S., N.A.C.A., Technical Note No. 1782*, January, 1949. 44 pp., illus., diagr., figs. 5 references.

At a gross load corresponding to 75,000 lbs., an increase from 6 to 15 of the length-beam ratio of a hypothetical flying boat reduced the maximum vertical accelerations during landing by approximately 25 per cent. The maximum angular accelerations during landing increased from 15 to 30 per cent, but the motions in trim and rise, as well as the maximum trim and rise, decreased. In waves 2 ft. high and 110 ft. long, the range of speed and load

(*Continued on page 94*)

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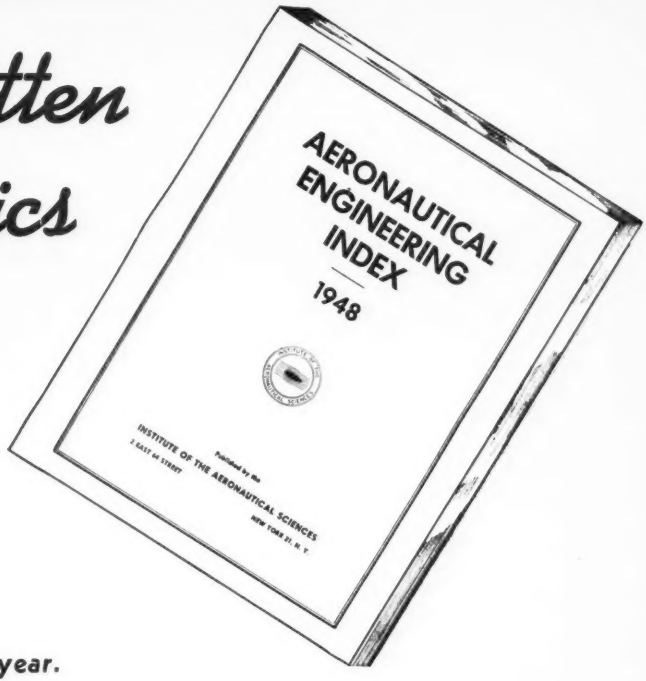

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Aeronautical Reviews

Books

Reissner Anniversary Volume: Contributions to Applied Mechanics

Edited by the Staff of the Department of Aeronautical Engineering and Applied Mechanics of the Polytechnic Institute of Brooklyn. Ann Arbor, Mich., J. W. Edwards, 1949. 493 pp., diagrs. $6.50.

There is a charming custom, practiced more frequently in the United States since the recent increase in the number of European scientists in our midst, of publishing an Anniversary Volume in honor of a man who has reached a certain maturity in his career. To deserve an Anniversary Volume, the scientist must be, first of all, distinguished, respected, well liked by his colleagues; second, he should be industructible. Professor Hans J. Reissner meets these requirements on all scores. The list of his serious and varied publications in many fields of applied mechanics and in several languages covers some eight pages in the Anniversary Volume, and on his seventy-fifth birthday Professor Reissner is carrying a full load of teaching and research to the great benefit of his associates and students.

What can one expect from such a volume, containing monographs (of an average of 20 pages each) by some 32 well-known men and embracing such varied fields as Aerodynamics, Dynamics, Elasticity and Structures, Electricity, Mathematical Methods, Plasticity, and Propulsion? Certainly not the systematic treatment to be found in a textbook nor even the well-planned presentation of an N.A.C.A. Symposium. And it is impossible in these days of specialization that the best informed man interested in applied mechanics should find equal appeal in every report. No, the value of such an Anniversary Volume lies in the fact that it tells us what men working in different fields find of the greatest importance at the moment and in bringing us new valuable ideas in fields in which we do not specialize but which are akin to our own. The briefest of notes on some of the papers will prove this point fully.

Aerodynamics

Thus, aerodynamicists will note carefully from Henry G. Lew's "On the Compressible Boundary Layer Over a Flat Plate With Uniform Suction" that the boundary-layer thickness varies inversely as the suction coefficient v_0/U, thereby producing a thinner boundary layer and an increasingly stable flow with higher values of suction velocity. It has long been known that a mathematical analogy exists between the motion and resistance of a perfect fluid in a shallow tank and the motion of a perfect hydraulic gas. In another aerodynamics paper, D. P. Riabouchinsky writes on "Hydraulic Analogy of the Motion and Resistance of a Compressible Fluid as an Aid to Aeronautical Research" and has extended the analogy to the two-dimensional motion of a gas and has described some interesting experiments. S. Bergman makes use of the principle that the equations for the steam functions of a steady two-dimensional flow of a compressible fluid, which are nonlinear when considered in the physical plane, become linear when transformed to the hodograph plane in his "Tables for the Determination of Transonic Flow Patterns." Walter Tollmein also makes another attack on the hodograph method in "The Direct Hodograph Method in the Theory of the Flow of Compressible Fluids." In the paper by R. Paul Harrington and Paul A. Libby entitled, "The Shear Flow of a Perfect Fluid About a Circular Cylinder Near a Rectilinear Boundary," the authors determine the flow field about a circular cylinder near a rectilinear boundary parallel to the undisturbed portions of a uniform shear flow and describe the flow field in terms of dipolar coordinates.

Dynamics

Martin Goland, in "Stick-Fixed, Short-Period Stability Based on the Wagner Air Forces," goes deeply into the problem. He does *not* presume that the instantaneous values of the aerodynamic loads can be adequately described in terms of the prevailing angles of attack at the lifting surfaces. Paul Lieber and M. E. Hamilton, "On the Dynamics of Aircraft Structures," present an effective two-dimensional method for calculating the deflections, velocities, and accelerations of a wing due to impact when an airplane makes a three-point landing. The titles of the other three papers on Dynamics speak for themselves: Rufus Oldenburger, "A Method of Obtaining Constant Speed From a Variable Speed Source"; D. Williams, "Rapid Estimates of the Higher Natural Frequencies and Modes of Beams and Hence of the Stresses Induced by Transient and Periodic Loads"; and S. W. Yuan and M. Morduchow, "On the Stability of the Transient Motion of Helicopter Blades in Flapping and Lagging."

Elasticity and Structures

It was not an accident that a large portion of the book is devoted to Elasticity and Structures, since Dr. Reissner, active in many fields, was pre-eminent in this one. To the initiated, the titles of the papers alone will give a clue to the wealth of material presented: L. H. Donnell, "The Critical Axial Compression or Tension on a Bar, for All Possible Positive and Negative End Fixities"; K. O. Friedrichs, "The Edge Effect in the Bending of Plates"; R. Gran Olsson, "Remarks on the Deflection Theory of Suspension Bridges"; Eric Reissner, "On the Theory of Thin Elastic Shells"; A. Schleusner, "On a Problem in the Theory of Earth Pressure"; George Schnadel, "The Strength of Transversely Stiffened Decks of Ships"; and J. J. Stoker, "Pre-Stressing a Plane Circular Plate to Stiffen It Against Buckling."

Electricity

For aeronautical people, it is sufficient to quote two electrical papers by title: "The Average Impedance of an Electrical Network," by Ronald M. Foster; and "The Electron Gun as Illuminator for Electron Microscopy," by Reinhold Rudenberg.

Mathematical Methods

It is extraordinary how rapidly the weapons of modern applied mechanics and advanced engineering have increased in scope and power. The *Reissner Anniversary Volume* provides three memoirs of interest to those who are mathematically inclined. The paper "On the Solution of Systems of Linear Equations by

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Certain Iteration Methods," by Hilda Geiringer, establishes some new convergence criteria for solving linear systems by iteration. A vector can be simply represented; now R. Grammel attempts, and apparently achieves, "A Simple Representation of Tensors and Affinors (Dyadics)." Computing frequencies of vibrating electric systems and buckling loads of structures has been a favored pastime for two centuries; Alexander Weinstein describes a new and powerful method of computation, "Separation Theorems for the Eigenvalues of Partial Differential Equations."

Plasticity

The last Annual Meeting of the Institute gave proof of interest in this subject. R. von Mises, in "Three Remarks on the Theory of the Ideal Plastic Body," adds to the general theory of the subject, while A. Nadai's "Theory of the Plastic Distortion of Thick-Walled Cylinders" reviews and extends the problem of permanent distortion of heavy-walled cylinders under pressures which brings stresses into the plastic region. The title of the report by Folke K. G. Odqvist, "Plasticity Applied to the Theory of Thin Shells and Pressure Vessels," speaks for itself.

Jets

Theodore von Kármán, with his usual grasp of first principles, discusses, in "Theoretical Remarks on Thrust Augmentation," the simplest case of a cylindrical tube with an entrance nozzle on the upstream side and a jet injected into the tube. He comes to this interesting conclusion: "The augmentation in the case of nonuniform distribution can be considerably larger than in the case of uniform distribution." Pulse-jet engines remain somewhat of a mystery. Hence, Paul Torda's "Compressible Flow Through Reed Valves for Pulse Jet Engines" is a welcome investigation of ways and means of increasing the air-intake efficiency of pulse-jets.

The *Reissner Anniversary Volume* is well written and well edited throughout. It provides a wealth of informative reading for advanced students, teachers, or research men. It is definitely not suited for those seeking an elementary or even simplified approach.

Dr. Alexander Klemin
Consulting Engineer
Greenwich, Conn.

The Flight of Birds Analyzed Through Slow Motion Photography

By John H. Storer. (Cranbrook Institute of Sciences, Bulletin No. 28.) Bloomfield Hills, Mich., Cranbrook Press, 1949. 93 pp., 170 illus. $2.50.

John H. Storer and the Cranbrook Institute of Sciences are to be congratulated upon the production of this compact and informative book. There

exists in this country a need for a more extended and serious attention to this phase of the aeronautical sciences. The book will therefore be of permanent value and interest to the technically trained, as well as to the lay public. To the many in both groups who have gazed in awe and wonder at the performance of birds, Mr. Storer will bring further interest and satisfaction.

Essentially, the volume consists of groups of selected pictures of bird flight, followed by a detailed analysis of the wing actions based upon elementary aerodynamics. The book is therefore the answer to the oft-repeated question, "Why don't they study bird flight by the slow-motion photograph?"

Preparatory to the analysis, there is a section dealing briefly with aerodynamics. There are also fine chapters on the feather structure of the wing and on gliding and soaring flight. In the latter chapter the author makes a clear presentation of the work of Alfred Woodcock. The limitations of the camera, of course, force him to forego approaches to the other important areas of the problem, such as functional anatomy and physiology, dynamics, and mathematical solution of the problem.

It is therefore to be hoped that this will prove to be the beginning of a series of such reports under the auspices of the Cranbrook Institute. For example, the author's mastery of the art of photography could well be employed in further studies aimed at the development of techniques for visualizing airflow about the bird in flight. The ability of the author and the Cranbrook Institute to enlist the aid of such an eminent group of collaborators augurs well for success in this field, which demands the services of a wide range of talents.

American books in this field are limited both in number and in comprehensiveness. We have never produced, for example, anything comparable with A. Magnan's *Le Vol des Oiseaux et des Avions* (1934). A book that presents room for interesting comparisons is Gordon Aymar's *Bird Flight*, published in 1935. While the present volume leans largely on the slow motion picture, Mr. Aymar dealt largely with the high-speed snapshot. A study of the two reveals that they are complementary rather than exclusive media of observation. The snapshot provides greater clarity of detail but offers less chance of providing the exact position wanted for analysis. It would be just to remark that Mr. Storer's motion pictures are much superior to those of the Magnan work mentioned. In this, the observational phase of the work, the author has performed a permanent and outstanding service.

We may proceed now to a discussion of his method of interpretation and conclusion based upon these observations. On page 28 the author states, "The first step in understanding bird flight is to think of the bird as a living airplane." This would definitely place him in the school of thought which might be entitled, "Aviation, the Basis of Bird Flight," in contrast with that school represented by O. Lilienthal, whose work entitled "Birdflight, the Basis of Aviation," exposes his approach. That the schools are not wholly in opposition is clear, for their common foundation lies in the science of aerodynamics. This, however, is yet a growing science and one with gaps in many areas. It has naturally grown most fully where practical needs were strongest, and, as a consequence, the great body of experimental knowledge is centered about the type of airflow applicable to the modern airplane. Undoubtedly, much of this may be validly applied to the interpretation of bird-wing phenomena, and this is the practice followed by the author and his collaborators.

To what degree may we implicitly rely upon this method?

The answer to this question will probably not be achieved for many years to come. Its elucidation demands a huge program of free and controlled flight observation, experimental work, and mathematical analysis.

The conclusions and principles of modern aerodynamics are limited in their application by the initial experimental conditions and by the mathematical assumptions involved. For example, the principles cited by

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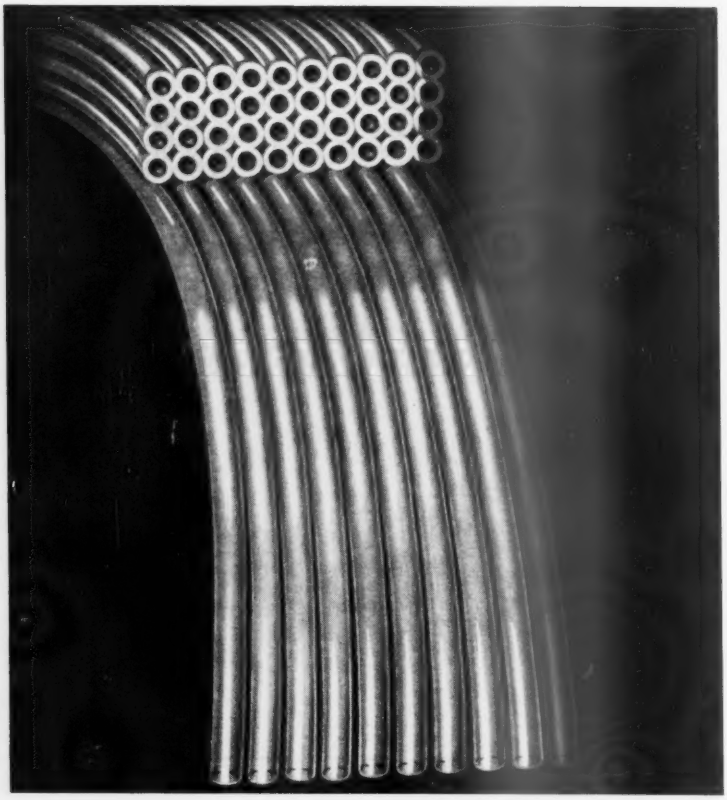

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the author have, among other basic assumptions, the following that are relevant to this application:

(1) Uniform span loading with two-dimensional airflow (excepting the tip vortex).

In the application, however, we find nonuniform span loading. (What type of lateral flow is introduced? Does it set up columnar or other vortical circulation with a vertical or partly vertical axis? Assuming the handwing propeller action, what happens when we enclose the main lifting members in the slipstream?)

(2) Steady-flow conditions with normal lift circulation.

In the application we find rapid variations of effective angles of attack during flapping flight, as well as periodic acceleration values ranging up to 4 *g* as measured by A. Magnan. (What happens to Prandtl's vortex sheet? Since the wing, according to Prandtl, will throw off a reversed vortex with each reversal of movement, is there any possibility that such an operation recaptures vortical energy over the whole or part of the span? How will this reversal of vortical structure affect the tip condition? How does this all relate to the Katzmayr effect with its occasional negation of induced drag? Do the vortex streets of von Kármán, together with the experimental studies of Fage and Johansen, suggest a timing for its recovery?)

(3) Rigid airfoils.

In the application we find nonrigid airfoils, hinged and possessing elastic connective tissue capable of storing energy.

(4) Smooth, inelastic, and impermeable surfaces.

In the application we find relatively rough, resilient surfaces, semipermeable over a part of the surface. (What does all this do to the important boundary layer? Does the semipermeability allow an upward air seepage and so control incidence of separation by pressure?)

(5) Straight leading edges.

In the application we find a cranked monospar wing with variable angles in all planes.

(6) Conventional airfoils such as Clark Y or similar NACA series without abrupt changes in curvature.

In the application we find a rather Joukowski-like airfoil, with automatic variable camber involving energy storage and most likely possessing the well-known rapid center-of-pressure travel characteristics of this series.

(7) The general assumption that nearly all vortices will be dissipative in nature.

Should we ignore the "rams horn vortex" of Lilienthal and verified by Sänger in the Vienna Wind Tunnel? Does the mathematical work of M. J. M. Hill (1894), M. S. Smolchowski (1912), and W. Rbezynski (1911) have any applicability? The work of Smolchowski could, for example, furnish an equally attractive

explanation for the V formation of the Brown Pelicans shown on page 72.

Enough has been said to convey the magnitude of the task ahead and to express again the hope that Mr. Storer and the Cranbrook Institute will move onward.

The only omission of any consequence which I note is the section on gliding and soaring. Here the author follows the lead of most American writers and ignores the contributions of Louis Brequet, whose mathematical treatment of dynamic soaring in his book *Le Vol à Voile Dynamique des Oiseaux* (1925) has stood unique and unchallenged for over 25 years. This, together with the experimental studies of Magnan, Hugenard, and Planiol on the internal structure of the wind, deserves a place in any discussion of dynamic soaring.

No conclusion could surpass the words of Ludlow Griscom, who, in the forward of the book, writes: "While, therefore, mystery and much wonder remain for those with minds open to the marvels of the natural world, this mystery itself will stimulate the reader to reflect on Mr. Storer's excellent book. He will not have read it in vain. His store of information will have been enriched and some elements of his curiosity satisfied."

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Book Notes

AIR TRANSPORTATION

Airport Planning; Domestic Air Cargo. Washington, Civil Aeronautics Administration, Office of Airports, December, 1948. 54 pp.

This study presents the available data on domestic air cargo for use as a guide in determining the airport requirements of specific communities, including the relative air-cargo possibilities of the commodities of American commerce, the air-cargo potential of 50 major U.S. communities, and the estimated air-cargo tonnage for these communities in 1955. Twelve air-cargo rating groups are established, and all commodities susceptible to transportation by air are assigned to them, with indications of the relative importance of each commodity for the air-cargo potential. Forecasts are made for the generated air cargo and air-cargo tonnage in 1955 by commodity classifications. The 50 communities are forecast to account for 76 per cent of all generated and 55 per cent of all terminated domestic air-cargo tonnage, with the generation, in 1955 of 878,600 tons of air cargo and the receipt of 740,000 tons.

Aircraft Dispatcher Rating. Charles A. Zweng. North Hollywood, Calif., Pan American Navigation Service, 1949. 427 pp.

Three-fourths of this book consists of the civil air regulations essential to the dispatcher, including Aircraft Dispatcher Certificates, Air Carrier Operating Certification, Air Carrier Operating Rules Outside the U.S.A., Non-Scheduled Air Carrier Operation, General Operation Rules, Air Traffic Rules, and Scheduled Air Carrier Rules. *Manual 60* on Air Traffic Rules, and Army-Navy C.A.A. Standard Airport Traffic Control Procedures are included. Sections on air-navigation radio aids and the fundamentals of navigation and meteorology are presented. The final section deals with typical multiple-choice examination questions and answers illustrating for the applicant the scope of the Government examinations.

ATOMIC ENERGY

The Science and Engineering of Nuclear Power. Vol. II. Edited by Clark Goodman. Cambridge, Mass., Addison-Wesley Press, Inc., 1949. 341 pp., illus., diagrs. $7.50.

This second volume of seminar notes for a course given at the Massachusetts Institute of Technology considers specific aspects of chain-reacting systems in 17 chapters by specialists. Reviews of unclassified literature on the energy release of the fission process, electromagnetic methods of separating isotopes, and the number of secondary neutrons per fission and their energy distribution are included in an appendix, and there is a 24-page index. Contents: Source Materials for Nuclear Power, Roland D. Parks; Isotope Separation, Karl Cohen; Vacuum Technique in Nuclear Engineering, Fontaine C. Armistead; Theoretical Basis of Some Measurements Useful in Pile Design, F. L. Friedman; Research in Neutron Physics at Chalk River, B. W. Sargent; Calculation of Neutron Distribution in Heterogeneous Piles, A. M. Weinberg; The Concept of Albedo in Elementary Diffusion Theory, by G. Placzek; Pile Kinetics, Harry Soodak; Statistical Aspects of Pile Theory, by Frederic de Hoffmann; Heat Removal from Nuclear Reactors, by E. R. Gilliland, D. Baresis, and G. Feick; Rockets and Other Thermal Jets Using Nuclear Energy, Hsue-Shen Tsien; The Shielding of Nuclear Reactors, M. L. Goldberger; Effects of Radiation on Materials, A. O. Allen; Production of Radionucleides, John W. Irvine, Jr.; Pile Materia's: Metals, Alloys and Compounds, by A. R. Kaufmann; Health Physics: Instrumentation and Hazard Evaluation, Robley D. Evans; and Future Developments in Nuclear Energy, Clark Goodman.

Atom. Constantin Paul Lent. New York, Pen-Ink Publishing Company, 1948. 32 pp., diagrs. $2.75.

The author's purpose is to present a semitechnical and popular exposition of atomic fission. Facts known to the ancient scientists and the work of the modern scientist are outlined, including explanations of the elements of astrophysics and the part played by electricity. A brief survey of the practical uses of atomic fission is included. The text is accompanied by drawings.

ELECTRONICS

Components Handbook. Edited by John F. Blackburn. (Massachusetts Institute of Technology, Radiation Laboratory Series No. 17.) New York, McGraw-Hill Book Company, Inc., 1949. 626 pp., illus., diagrs. $8.00.

This volume is intended as a companion and reference work for other volumes in this series on Vacuum Tube Amplifiers, Waveforms, Electronic Time Measurements, Electronic Instruments, Cathode Ray Tube Displays, and Microwave Receivers. Data are presented on various classes of electrical and electronic components that are of principal interest to the designer of receiving and test equipment. The 14 chapters deal with Wires and Cables, Fixed Composition Resistors, Fixed Wire-Wound and Miscellaneous Resistors, Iron-Core Inductors, Piezoelectric Devices, Electromagnetic Delay Lines, Supersonic Delay Lines, Potentiometers, Special Variable Condensers, Rotary Inductors, Instrument Motors and Tachometers, Power Supplies, Relays and Related Devices, and Receiving Tubes. Footnote references are included throughout.

Radio Engineering. E. K. Sandeman. New York, John Wiley & Sons, Inc., 1948. 775 pp., diagrs. $6.50.

Intended originally as a manual for maintenance engineers of The British Broadcasting Corporation, this book was enlarged to make it a reference volume for engineers and designers. A working knowledge of elementary algebra and logarithms is expected of the reader. The emphasis is upon practical information on design, methods and essential formulas. The discussion includes practical methods of adjusting class-C amplifiers and modulated amplifiers, operation of transmitters, adjustment of different types of capacity neutralizing circuits, theory of oscillators, mode of operation of multivibrators, design of coupled circuits, lining up antenna circuits of various wavelengths, feedback, filter design, harmonic analysis of various standard waves, resonant circuits, equalizer design, line transmission theory, peak voltmeter design, the concept of impedance from the physical standpoint, radio-frequency resistance, inductance of straight wires, impedance characteristics of feeders, and curves for finding the spectra of frequency-modulated waves.

Ionospheric Research at Watheroo Observatory, Western Australia, June, 1938–June, 1946. L. V. Berkner and H. W. Wells. (Carnegie Institution of Washington, Department of Terrestrial Magnetism, Researches, Vol. 13, Publication No. 175.) Washington, Carnegie Institution of Washington, 1948. 425 pp., illus. Paper, $2.00; cloth, $2.50.

The tables presented include data on the critical frequency of ordinary wave component (F_2 layer) and minimum virtual height (F_2 layer) on a full 24-hour per day basis, critical frequency (F_1 layer), minimum virtual height (F_1 layer), critical frequency (normal E layer), and lowest frequency at which reflections are recorded, for daylight hours only, centered around noon. Night values for the first two categories on the 24-hour basis are represented after the F_1 and F_2 layers have merged. As E-layer heights can usually be assumed at 100 km., these are not included in the tabulations. Apparatus and methods used are described, and there is a comprehensive bibliography.

ENGINEERING PRACTICES

Blueprint Reading. Department of Education, International Business Machines Corporation. Syracuse, N.Y., Syracuse University Press, 1946. 81 pp., illus., diagrs. $3.75.

Based on individual lessons developed in 1934 and frequently revised in keeping with actual classroom experience, this textbook presents a concise course in the basic knowledge needed to read blueprints used in the metalworking industries. Emphasis is laid upon the necessary mathematics, including geometry, and photographs and blueprints as employed in industry are used extensively.

INDUSTRIAL RELATIONS

Survey of Personnel Practices in Los Angeles County, as of August 1, 1947, compiled by Richard O. Sensor and Mary Faith Martin. (Bulletin No. 14.) Pasadena, Calif., California Institute of Technology, Industrial Relations Section, 1948. 45 pp. $2.50.

This survey covers 524 employers of 351,143 workers, in 19 specific manufacturing categories and six specific nonmanufacturing categories, including 34 manufacturing and 23 nonmanufacturing employers not specifically classified. Four aircraft manufacturers and ten aircraft parts manufacturers, accounting for 55,940 and 3,472 employees, respectively, are included. The data include, for hourly and salaried workers, work schedules, Saturday work, premium pay, wage schedules, holiday pay, shift differentials, and union representation. Vacations with pay, sick leave, and benefit plans are omitted.

LAWS & REGULATIONS

Patent Law for Lawyers, Students, Chemists, and Engineers. Chester H. Biesterfeld. 2nd Ed. New York, John Wiley & Sons, Inc., 1949. 267 pp. $4.00.

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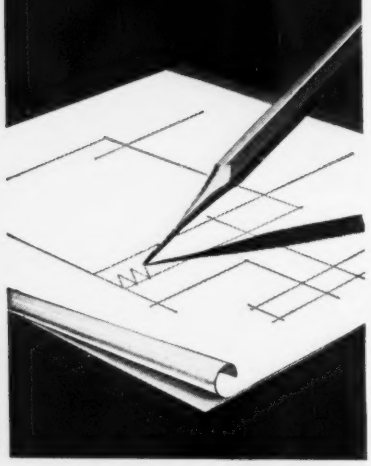

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The aim of this volume, which was first published in 1943, is to present the basic principles of the substantive law in terms understandable to the general reader, supported by selected decisions of the U.S. Supreme Court and the Federal Courts of appeal. Revisions in this edition have been extensive, including new material and changes in the chapters on Uses, Double Patenting, Disclaimers, Infringement, Trade Secrets, and Patent Litigation. In the chapter on Liability for Infringement, the former discussion on profits, made obsolete by Congress in August, 1946, has been omitted, and damages are discussed in more detail. This edition, like the first, is based on lectures given at the University of Delaware.

Patent Law for the Executive and Engineer. H. A. Toulmin, Jr. 2nd Ed. Dayton 2, Ohio, 137 N. Perry St., Research Press, Inc., 1948. 231 pp. $2.95.

This book was first published in 1928 and has been reprinted several times. This is its first revision. Although the author is a patent lawyer, it is written in nontechnical language and is designed primarily for the business man. In addition to chapters on procedures in obtaining and protecting patents, which include procedures on foreign patent protection, several chapters are devoted to special problems, such as Who Owns the Invention—The Employer or the Employee? How to Stimulate Invention by Employees, Having Inventions Made to Order, Patent Pools, and How to Determine When a Development Is an Invention.

MANAGEMENT & FINANCE

NATA Manual of Standard Accounting Procedure. Washington 6, D.C., National Aviation Trades Association, 1948. 48 pp. $12.

The purpose of this manual is to provide a basis for bookkeeping and accounting policies and practices in various types of aviation business activities and particularly in those dealing with flight education and training. General instructions are followed by a chart of accounts; then by descriptions of general ledger accounts, revenue accounts, direct-cost and indirect-cost accounts, operating-expense accounts; and, finally, by explanations and examples of accounting forms and financial statements.

MATERIALS

Elasticity and Anelasticity of Metals. Clarence Zenev. Chicago, University of Chicago Press, 1948. 170 pp., diagrs. $4.00.

To avoid the connotation of a permanent set after removal of all stress in the nonelastic behavior of metals, the term "anelasticity" has been chosen, denoting the property of a solid in virtue which stress and strain are not uniquely related in the preplastic range. Although some of the data in this book have appeared before, this is the first connected and thorough treatment of the whole subject. The first part deals with the elasticity of metals, including formal relations between stress and strain, low-temperature elastic constants in cubic metals, temperature dependence of elastic constants, and a previously unpublished discussion of microelasticity. Part 2, taking up three-fourths of the book, considers the formal theory of anelasticity of metals and measurement of the relaxation spectrum, including the relation between measures of internal friction, measurement of internal friction, and variation of frequency. The discussion of the physical interpretation of anelasticity covers homogeneous relaxation, including the general theory of relaxation by diffusion; relaxation by thermal diffusion, atomic diffusion, and magnetic diffusion; and relaxation of ordered distributions and preferential distributions. In the section on inhomogeneous relaxation, the concept of two-component systems is discussed, followed by stress relaxation along previously formed slip bands, across grain boundaries, and across twin interfaces. About 170 footnote references are given, and there is an author and subject index.

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Engineering with Rubber. Edited by Walter E. Burton, in collaboration with engineers and research men of The B. F. Goodrich Company. New York, McGraw-Hill Book Company, Inc., 1949. 486 pp., illus., diagrs. $6.50.

In this work the emphasis is placed on various types of rubber products such as adhesives, latex products, v-belts and sheaves, belting, extruded rubber, hard rubber, rubber hose, lathe-cut rubber, linings, molded rubber, packing and sheet rubber, sponge rubber, and rubber thread and tape. Applications are included throughout and are covered generally in the chapters on rubber mountings, rubber in hydraulic equipment, rubber printing materials, and rubber-covered rolls. Numerous data tables and illustrations are given.

POWER PLANTS

Gas Turbines and Their Problems. Hayne Constant. London, Todd Publishing Group, Ltd., 158 pp., illus., diagrs. 7*s.* 6*d.*

The purpose of this book is to explain on a physical, rather than a mathematical, basis the special problems of the gas-turbine system, its advantages and limitations, the processes that are understood, and the difficulties that still have to be overcome. Following chapters on Early History, The Advent of the Aircraft Gas Turbine, and The Present Position of the Gas Turbine, the more specific aspects are taken up in chapters on Thermodynamic Cycles, The Compressor, The Turbine, Ducting, Combustion, The Heat Exchanger, Mechanical Design, Applications of the Gas Turbine, and The Future. The author, who is Deputy Director of the British National Gas Turbine Establishment, feels that, in order to concentrate rather than disperse the development effort, choices must be made between the available alternatives for development, as between centrifugal, axial, radial, and mixed flow compressors; between axial and inward-flow turbines; between heat exchangers of conduction and capacity types with plate and tube surfaces; between refractory and metal combustion chambers of annular and cylindrical shape; and between bladings of great variety and form.

Theory and Practice of Heat Engines. Virgil Moring Faires. New York, The Macmillan Company, 1948. 388 pp. illus., diagrs. $5.00.

This textbook is designed primarily for students taking a terminal course in heat power and is applicable for a preliminary course to theoretical thermodynamics. In order to emphasize the law of conservation of energy, the general energy equation is applied consistently throughout. Derivations and explanations of most equations are given, one exception being the case of the expression for the critical pressure in a nozzle. Among the applications discussed are internal-combustion engines, including gas turbines, steam turbines, reciprocating steam engines, steam power-plant equipment, and refrigeration. Textbook references and problems are provided after each chapter.

PRODUCTION

Some Basic Techniques in Materials Handling; Proceedings of the Technical Sessions Held Concurrently With the Second National Materials Handling Exposition, Cleveland, January, 1948. New York, 350 5th Avenue, Clapp & Poliak, Inc., 1948. 84 pp., illus., diagrs. $1.00.

Eighteen papers are presented on current industrial practices in materials handling, including discussions of plant layout, freight-elevator operations, materials-handling surveys, storeroom operation, the pallet system, pallet sizes, packaging, time and motion study, standardization of equipment, handling unusual shapes, integration of types of equipment, and loss and damage prevention.

REFERENCE LITERATURE

A Checklist of Aeronautical Periodicals and Serials in the Library of Congress. Arthur G. Renstrom. Washington, Library of Congress, Reference Department, Aeronautics Division, 1948. 129 pp.

A total of 1,585 separate titles are listed, from 52 countries, of periodicals, serial university and monograph publications, Government publications, house organs, and publications of aeronautical organizations and societies. General technical and popular journals, administrative reports, annual reports, and yearbooks have been excluded.

Statistical Handbook of Civil Aviation, 1948. U.S. Civil Aeronautics Administration. Washington, U.S. Govt. Printing Office, 1948. 121 pp., maps, charts. $0.50.

This edition contains all available statistics through the calender year 1947 and replaces the edition of 1945, with its two supplements. The present edition is the most useful yet issued, affording retrospective and current tables and charts on airports, federal airways, aircraft and airmen certifications, flight and ground training, civil flying, production and exports, scheduled air-carrier operations, and accidents. Statistics in all categories pertaining to scheduled air-carrier operations and accidents prior to 1938 have been reworked to conform with the classifications and groupings of Civil Aeronautics Board data, and a number of new tables have been added in other places. In most cases, data begin about 1926, but aeronautical production and export data begin in 1913. Sources of all data are given.

Standard Handbook for Electrical Engineers. Archer E. Knowlton, Editor-in-Chief. 8th Ed. New York, McGraw-Hill Book Company, Inc., 1949. 2,311 pp., diagrs. $12.

This is the first revision of this excellent handbook since 1941. Developments of the war have been incorporated into this edition, as airplane power distribution, servomechanisms, radar and microwave techniques, nuclear energy, induction and dielectric heating, and airport and airway lighting. New magnetic materials, insulations, and standards in various fields are included, and extensive revisions have been made in sections on conductors, generators, transformers, and interior wiring. The bibliographies have been revised throughout, and the index has expanded by 25 per cent. The original plan of the book has been retained, and the original aim, to present working information in convenient and brief form, has been admirably fulfilled.

Way of a Fighter, the Memoirs of Claire Lee Chennault. Edited by Robert Hotz. New York, G. P. Putnam's Sons, 1949. 375 pp., illus. $4.50.

The greater part of General Chennault's memoirs is written about his career in China, taken up after his retirement from the Air Corps in 1937. There his theories of fighter tactics and strategy made their mark in the legendary achievements of the "Flying Tigers," and the Chinese Air Force and civil air transport came into being in no small measure because of his work. The Chinese phase of his career is familiar through the newspapers. Less is known of his early Air Corps career, his early work with paratroop and fighter tactics, his championship of the role of the fighter airplane in war, and, going further back, his typically individualistic bootlegging of flying time until he was accepted as a fighter pilot. Going still further back, Chennault as a boyhood fisherman, athlete, and hunter, who shot his first rifle at the age of eight, is even less known. More about the man who never fails to fish at least one Louisiana river on trips to the United States would be entirely welcome.

SCIENCES, GENERAL

MATHEMATICS

Six Studies in Mathematics. (University of Washington Publications in Mathematics, Vol 3, No. 1.) Seattle, University of Washington Press, 1948. 54 pp. $1.50.

Contents: The Parametric Treatment of Cyclic-Harmonic Curves, R. M. Winger; The Transversality Condition of the Calculus of Variations, L. H. McFarlan; On Certain Stieltjes

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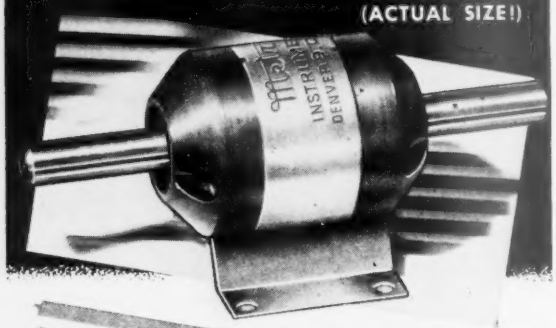

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Integral Equations, Fumio Yagi; An Icosahedron Space, J. M. Kingston; On the Determination of the Dependence of a Disease, Especially Cancer, On Age, Z. W. Birnbaum and Herbert S. Zuckerman; On Systems of Partial Differential Equations, Clyde M. Cramlet, Ethel C. Muggli, and Herbert S. Zuckerman.

MECHANICS — VIBRATION

Elements of Mechanical Vibration. C. R. Freberg and E. N. Kemler. 2nd Ed. New York, John Wiley & Sons, Inc., 1949. 227 pp., illus., diagrs. $3.75.

The first edition of this textbook was published in 1943. The original purpose, to discuss the more elementary phases of vibrations and reduce them to a form applicable to practical problems, has been continued. The methods presented do not require a knowledge of higher mathematics, and the problems can be solved by the use of the simpler forms of differential equations, by the approximate methods developed, and by the mobility method. In the present edition, a chapter on the engineering aspects of sound and noise elimination has been added, and the material on beams has been augmented and presented as a separate chapter, in addition to changes and corrections throughout. The authors are with the Southern Research Institute and New York University, respectively.

PHYSICS

Foundations of Modern Physics. Thomas B. Brown. 2nd Ed. New York, John Wiley & Sons, Inc., 1949. 391 pp., illus. $7.00.

In this new edition of a textbook first published in 1940, the approach to modern physics largely by the description and analysis of experiments is retained. A knowledge of algebra and geometry is required of the reader but not advanced mathematics. New material has been added in chapters dealing with the kinetic theory of gases, electronics, microwaves and radar, nuclear energy, and cosmic rays. The bibliographies at the ends of chapters have been revised, and numerous bibliographic footnotes have been added. The author is a professor at George Washington University.

Scientific Foundations of Vacuum Technique. Saul Dushman. New York, John Wiley & Sons, Inc., 1949. 822 pp., diagrs. $15.

The author's purpose is to present a survey of the fundamental ideas in physics, chemistry, and, to some extent, metallurgy, which will be of use to the scientist and engineer dealing with problems in all phases of producing, maintaining, and measuring very low gas pressures. The first two chapters deal with the Kinetic Theory of Gases and the Flow of Gases Through Tubes and Orifices. Mechanical Pumps, Steam-Jet Injectors and Mercury-Vapor Pumps, Vapor Pumps Using Organic Liquids, and Manometers for Low Gas Pressures are next discussed. Two chapters follow on the sorption of gases and vapors by solids, "active" charcoal, silicates, and cellulose. The final third of the book consists of chapters on Gases and Metals, Chemical and Electrical Clean-Up of Gases at Low Pressures, Vapor Pressures and Rates of Evaporation, and Dissociation Pressures of Oxides, Hydrides, and Nitrides and Rates of Oxidation. Over 1,200 footnote references are included, as well as indexes of authors and subjects. The author is Assistant Director of the Research Laboratory, General Electric Company.

Fundamentals of Light and Lighting. Walter Sturrock and K. A. Staley. (Bulletin LD-2.) Nela Park, Cleveland 12, Ohio, General Electric Company, Lamp Department, 1948. 86 pp. illus., diagrs. $1.00.

This is an outline of fundamentals of the physics of light and its measurement, methods of control, characteristics of materials used in lighting equipment, and the principles of illumination design. The illustrations and diagrams, many of them colored, are excellently done, and tabulations of design data are included.

Letter to the Editor

Dear Sir:

Because of my natural prejudice in the matter, I have hesitated to write you with regard to the review of my book, *High Speed Aerodynamics*, which appeared in the December, 1948, issue of your magazine. Perhaps the best way to express my opinion of this review would be to quote from an unsolicited, joint letter written to the REVIEW by Joseph Flatt and Richard Klepinger, of the Aircraft Laboratory at Wright Field, whose competence in applied high-speed aerodynamics will not be questioned by the reviewer of my book. Their letter, a copy of which was sent to me, says, in part:

"We are well acquainted with Professor Sibert and the calibre of his work and feel that the above review is a great injustice to both. First of all, the book was written with the express intention of being used by undergraduate students in *applied aerodynamics*. It is obvious that this book has been reviewed from the standpoint of classical aerodynamics only. Consequently, the standards used in the evaluation of the book were improper and unfavorable."

The author is grateful to the reviewer for pointing out the error in the proof of the Prandtl-Glauert formulas, which had been overly simplified to make it understandable to undergraduate students. The other errors that the reviewer pointed out are of a minor nature and are of the type that most reviewers would send privately to the author to help him correct the errors that always occur in a new book.

PROFESSOR HAROLD W. SIBERT
University of Colorado
Boulder, Colo.

I.A.S. National Meeting Schedule

Second Joint I.A.S.-R.Ae.S. Conference—New York—May 24–26

Annual Summer Meeting—Los Angeles—July 21–22

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

All correspondence should be addressed to
The Meetings Committee
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Student Branches

(*Continued from page 22*)

Chairman, Walter Geudtner. These included an intensive membership drive, a get-acquainted social with the faculty, and the writing of student papers for presentation at meetings. Other new officers are: Vice-Chairman, Russ Fahey; and Secretary-Treasurer, David Medivid.

Speaker for the evening was Frank N. Brown, Professor and Head of the Aeronautical Department, Notre Dame, who gave a talk on "The Aeronautical Department and the Student."

On March 8, Chairman Geudtner announced that plans for a regional meeting, to have been held at the University of Michigan, have been discontinued. A new site, he reported, is being chosen, either Purdue University or University of Notre Dame.

A film, *Little Henry*, by McDonnell Aircraft, was shown at the conclusion of the business meeting.

Oregon State College

With Chairman Curt Privett presiding, a Navy film on mechanical refrigeration was shown at the February 2 meeting.

At the February 26 meeting, Prof. Benjamin F. Ruffner, Head of the Department of Aeronautical Engineering, gave a talk on "The National I.A.S. Conference." Practically all commercial design has ceased, Professor Ruffner said, and industry is working on military design. His talk gave a brief review of the papers presented at the I.A.S. Annual Meeting.

Parks College of Aeronautical Technology

Chairman Frank Stienke introduced the main speaker of the February 10 meeting, Edward Barker, Registrar and Honorary Chairman, who spoke on "Your Future in Industry."

Polytechnic Institute of Brooklyn

Arrangements were made at the February 15 meeting for a conducted tour of the Navy's Special Devices Center at Sands Point, L.I., on March 4. The student members were served dinner at the B.O.Q. of the Navy Center before beginning the tour.

A film, *Target for Today*, was presented, depicting the planning and coordination required of a multitude of personnel to launch and execute successfully a bombing mission over Germany by the Eighth Air Force during the World War II.

Rensselaer Polytechnic Institute

Dr. Robert H. Scanlan, Associate Professor, Department of Aeronautical Engineering, gave a talk on "Flutter Vibrations" at the February 10 meeting, at which 100 were present. Ernest von der Heyden, Chairman, presided.

On February 17, Rear Adm. C. E. Rosendahl U.S.N. (ret.), gave a talk on "The Airship."

The Admiral proposes a fleet of airships of 10,000,000-cu.ft. capacity to be used both commercially and by the services. Commercially, the rigid airship can provide a safe and cheap type of ocean travel for passengers and cargo alike, he said. They would travel at a speed in between that of planes and surface vessels, offering a maximum in comfort to passengers and boasting a huge cargo capacity.

Airships, Admiral Rosendahl declared, can fly around storm areas and even hover in safety until the storm passes on. The services could use the rigid airship as aircraft carriers, troop carriers, and as electronic sentinels in the proposed radar "fence" round the country.

University of Southern California

"The North American B-45 Bomber" was the subject of a talk by C. J. Hansen, Assistant Chief Engineer—Administration, North American Aviation, Inc., at the February 16 meeting. The Chairman, Lewis A. Nelson, presided with about 100 present.

Mr. Hansen gave a résumé of the engineering facilities and personnel of North American. He then reviewed the development of the bomber, stressing the many new problems associated with the high-speed jet plane and the methods used at North American to overcome the difficulties.

Spartan College of Aeronautical Engineering

A "Review of the I.A.S. JOURNAL" was given at the February 1 meeting by Student Member John Terry. There were 61 members present, with Forrest D. Swisher, Chairman, presiding.

Stanford University

The February 23 meeting was given over to the presentation of papers by

student members. Murray Dryer, senior aeronautics student, presented a paper on "The Compressibility Bubble in Supersonic Flight"; Bob Clark, former Chief Aviation Machinist Mate in the Navy, gave one on "Aircraft Maintenance"; and Norman Abramson, on leave from the Guided Missile Test Center, Pt. Mugu, presented one on "Aerodynamic Problems Encountered in the Testing of Guided Missiles." Twelve members were present.

A. & M. College of Texas

On February 17, the guest speaker, A. I. Sibila, Chief Aerodynamicist, Chance Vought Aircraft Division, United Aircraft Corporation, was introduced by Faculty Sponsor, Prof. Edward E. Brush.

Topic was "Your Career in Aeronautical Engineering" in which the speaker first enumerated all the possibilities for employment in the aircraft and related industries. He emphasized the importance of specializing in some certain field, since the increasing complexity of modern aircraft has necessitated the employment of a large number of men to design each plane.

In making a choice of field, Mr. Sibila stressed the importance of picking the one field that was of the greatest interest to the student.

University of Toledo

At the February 10 meeting, three subjects were assigned for research and construction. These included: Supersonic Wind Tunnel; Schlieren Method of Flow Observation; and Jet Engine (West type). John Kozak presided as Chairman. Fifteen members were present.

Tri-State College

Final meeting of the winter term was held March 2, when plans were completed for the Term Banquet, to be held March 10. Plans also were made for the annual field trip to be held the latter part of this month. The film, *The Birth of the B-29*, was shown Edward C. Klein, Chairman, presided, with 28 members present.

The banquet for the Winter Term, held March 10, was at Potawatomi Inn, Lake James, Ind. Chairman E. C. Klein presided with 50 persons present.

Following the banquet, Chairman Klein presented membership certificates to the members eligible. Short talks were given by Honorary Chairman S. M. Acton and Prof. Q. J. Hawthorne, congratulating the graduating members. Honorary Chairman Acton announced his retirement as Honorary Chairman. Professor Hawthorne will be the new Honorary Chairman for the Spring Term.

Guest speaker of the evening was Major Lawrence D. Ely, U.S.A.F., Air Materiel Command, Wright Field. Major Ely, prior to his entry in the Air Force, was Head of the Aeronautical Engineering Department at Tri-State from 1935 to 1940. He chose as his subject, "Training Programs in the Air Force."

Following the talk, the Chairman-elect and new officers for the Spring Term were introduced: Chairman, Francis C. Townes; Vice-Chairman, William A. Setlock; Secretary, Kenneth Detweiller; Student Council, R. Wellbaum; Reporter, Edward Singer.

Virginia Polytechnic Institute

Chairman Cleo Boothe Wood called the February 22 meeting to order and then turned the floor over to Dr. Victor G. Szebehely, Assistant Professor of Applied Mechanics, who talked on "Education Systems." A film, *Report on Jet Propulsion*, was shown.

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Stanley Hiller, Jr. (right), President of United Helicopters, Inc., turns over the first commercial Hiller 360 to B. F. Hodges, Walnut Grove, Calif., rancher. Along with ownership papers, Rancher Hodges received a set of gold keys for the No. 1 commercial Hiller 'copter shown equipped with new jumbo-sized dusting and spraying bins.

News of Members

(Continued from page 23)

C. R. Smith is Missile Flight Test Engineer, Boeing Airplane Company, Seattle, Wash.

Fred W. Sturm, Jr., reports he is now living at 210 Woodmont Circle, Nashville, Tenn. He is associated in an executive capacity with the National Reinforced Plastics Corporation, Berry Field, Nashville. He was Assistant Chief Engineer, Winner Mfg. Co., Trenton, N. J.

Samuel J. C. Townsend is in Dallas with Chance Vought Aircraft Division of United Aircraft Corporation as Engineer-Supervisor.

M. J. Turner is in Dallas with Chance Vought Aircraft Division, United Aircraft, in his former capacity of Supervisor of Dynamic Analysis.

J. Carlton Ward, Jr., Chairman of the Board of Fairchild Engine and Airplane Corporation, gave an address on "The Economic Consequences of Air Power" March 7 at the Library of Congress, Washington, D.C.

Burdette S. Wright, former Curtiss-Wright Corporation Vice-President, has retired and is living at his home at Locust Hill, Leesburg, Va.

H. Russell Young is President, Young Testing Machine Company, Narberth, Pa. Previously he was Chief Engineer of Testing Machines—Wind Tunnels, Baldwin Locomotive Works.

Earle M. Zerbe resigned from his position with the U.S. Rubber Company and is with The Winkelmann Company, South Bend, Ind.

University of Virginia

At a special caucus, a charter was drawn up, and the following officers were elected December 18: Chairman, Earl E. Wlaker; Vice-Chairman, Harold S. Moore; Secretary, Richard C. Mapp; and Treasurer, Seymour Zeenkov.

At the February 22 meeting, James E. May, Faculty Advisor and Assistant Professor, gave a talk on "Organization of the National Society of the I.A.S."

University of Washington

"The Role of the Engineer in the Air Line" was the subject of an interesting talk by Jere Farrah, American Airlines Representative with Boeing Airplane Company, Seattle, at the February 15 meeting. Chairman Thomas Godfrey presided with 40 members present.

West Virginia University

The new Chairman, Clyde V. Hamilton, called the February 2 meeting to order and appointed the following committees to serve the spring semester: Membership Committee: Shaffer and Boggs; Meetings and Papers Committee: Shore and Thomas; Committee for Arranging Program for General Engineering Society: Law and Newcome; Nominating Committee for Officers to General Society: Cubbage and Lawson.

At the February 15 meeting, Mr. Lawson gave a report of the voting procedure for the election of officers to the General Engineering Society.

Members Elected

The following applicants for membership or applicants for change of previous grade have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Hall, Charles L., B.S., in M.E., Chief Project Engineer, Fighter Branch, Engineering Div., Air Materiel Command, Wright-Patterson Air Force Base.

Schoolfield, William C., S.B. in Ae.E., Chief of Aerodynamics, Chance Vought Aircraft Div., United Aircraft Corp.

Sharp, Edward R., D.Sc. (Hon.), Dir., Lewis Flight Propulsion Lab., N.A.C.A.

Elected to MEMBER Grade

Bell, Richard William, Ae.E., Chief of Experimental Div., Southern California Cooperative Wind Tunnel; Part-time Lecturer in Aerodynamics and Jet Propulsion, Guggenheim Graduate School of Aeronautics.

Brush, Robert Platt, A.A., Engineering Test Pilot and on Special Assignment at Flight Test Div., Douglas Aircraft Co., Inc.

Cotton, Robert B., B.S. in Ae.E., Chief Engineer, Engineering & Research Div., All American Airways, Inc.

D'Anna, Peter William, B.S. in A.E., Sr. Aircraft Designer, Goodyear Aircraft Corp.

Freitag, Louis F., Design Engineer (Landing Gear), The Glenn L. Martin Co.

Lew, John, M.E., Asst. Research Aero. Engineer, Composite Design Group, Research Lab., Cornell Aero. Lab.

Parramore, Eric George, Constructor, N.V. Verenigde Nederlandsche Vliegtuigenfabriek "Fokker."

Ringe, G. Truxton, B.S., Headquarters Aviation Representative, Westinghouse Electric Corp. (West Coast).

Scheider, Maurice George, B.S., Sr. Aerodynamics Engineer, The Glenn L. Martin Co.

Tingley, Richard C., Sr. Draftsman, A. V. Roe Canada, Ltd.

Tippett, Cloyce Joseph, South American Consultant, Bell Aircraft Corp.; Technical Dir., TAYR.

Wascavage, Joe A., B.S.E.E., Sr. Design Engineer, Goodyear Aircraft Corp.

Young, David Arthur, B.S. in M.E., Research Engineer, Supervisor, Liquid Rocket Research Group, Aerojet Engineering Corp.

Transferred to MEMBER Grade

Carvey, Thomas B., Jr., A.B. in M.E., Development Engineer, Hughes Aircraft Co.

Lynahan, Paul William, B. in Ae.E., Sr. Layout Designer, Air Frame Section, The Glenn L. Martin Co.

Marble, Frank E., Ph.D., Instuctor of Aeronautics, California Institute of Technology.

Myers, Dale D., B.S. in Ae.E., Asst. Chief, Aerodynamics, North American Aviation, Inc.

Probst, Joseph, B.S. in Ae.E., Stress Analyst, Grumman Aircraft Engineering Corp.

Wright, John A., B.S. in M.E., Acting Chief Engineer, Marine Aircraft Corp.

Elected to Associate Member Grade

Ball, Donald Thomas, Suggestion Investigator, American Airlines, Inc.

Brandt, Paul E., B.S. in Ae.E., Technical Advisor, Reynolds Metals Co.

Kelly, James Nelson, Executive Vice-President, Boots Aircraft Nut Corp.

McAvoy, James, Aircraft Engineer (Licensed), British European Airways.

McEnness, Harold F., Sales Mgr., Control Components, Kearfott Co., Inc.

Elected to Technical Member Grade

Brooks, Kenneth, Technical Asst., Weight Engineering Dept., Rolls-Royce, Ltd. (England).

Hartman, Creighton D., B.M.E., Research Engineer, Daniel Guggenheim Airship Institute.

Jaworksi, Henry J., B. of Ae.E., Asst. Prof., Preliminary Design & Layout, Spartan School of Aero.

Kaczanowicz, John Walter, M.E.(Aero.), Aero. Engineer, Flight Test Section, Power Plants, Naval Air Test Center (Patuxent River).

Rice, James A., B.A. Sc., M.E., Service Engineer, Canadian Pacific Airlines.

Stakee, William Edward, B.S. A.E., Design Engineer, In Charge of all Engineering in the Structural & Aero. Departments, Skyline Tower Co.

Transferred to Technical Member Grade

Adams, Laurence J., B.S., Jr. Stress Analyst, The Glenn L. Martin Co.

Agosta, Vito D., M.S. in M.E., Student, Dept. of Mechanical Engineering, Columbia University, and Consulting Engineer, Chemical Construction Co.

Anderson, Ray B., B.S. in Ae.E., Mathematician, Stress Dept., Northrop Aircraft, Inc.

Austin, Kenneth C., Engineering Draftsman "B," North American Aviation, Inc.

Bach, John H., Draftsman "A," Northrop Aircraft, Inc.

Bailey, W. Selkirk, B.A.E., Analytical Engineer, Research Dept., United Aircraft Corp.

Bauer, Paul W., Engineering Draftsman "B," Northrop Aircraft, Inc.

Becker, Henry K., B.Ae.E., Student, College of Education, University of Minnesota.

Beckington, Arthur R., M.S., Aerodynamicist, McDonnell Aircraft Corp.

Bornemann, William Edward, B.S. in Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Bowers, Robert William, B. of Ae.E., Aerodynamicist, Douglas Aircraft Co., Inc. (Long Beach).

Breyan, William, B.S., Jr. Development Engineer, Goodyear Aircraft Corp.

Bumstead, Richard, B.Ae.E., Jr. Engineer, Piasecki Helicopter Corp.

Buning, Harm, B.S. in Ae.E., Asst. Engineer, Engineering Research, University of Michigan Aero. Research Center.

Burkitt, William C., B.S. in Ae.E., Detail Engineer, Boeing Airplane Co. (Wichita).

Carey, Alexander M., B.S.E., Test Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Chelgren, David O., B. of Ae.E., Jr. Analytical & Research Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Coker, Murl J., Design Draftsman "B," North American Aviation, Inc.

Daly, Thomas.

Dean, Alden Smith, B.Ae.E., Engineering Draftsman "B," North American Aviation, Inc.

DeMuesy, Thomas Gray, B.S. Ae.E., Jr. Test Engineer, Steel Blade Group, Hamilton Standard Propellers Div., United Aircraft Corp.

Diamond, Marilee Zoe, B.S.E. (Aero.), Research Asst., University of Michigan Aero. Research Center.

Duffy, Robert T., Sr. Draftsman, Goodyear Aircraft Corp.

Edberg, James R., B.S.E.

Fedarko, William B.S., Jr. Engineer, Westinghouse Electric Corp.

Figler, Robert J., Engineering Draftsman, North American Aviation, Inc.

Fix, Dale E., Structural Designer, Carew Steel Products Corp.

Flynn, George W., Jr. Structural Engineer, Pilotless Plane Div., Fairchild Engine & Airplane Corp.

Gale, Austin Harold, B. of Ae.E., Analytical Engineer, Research Dept., United Aircraft Corp.

Glose, C. William, Weight Analyst, Northrop Aircraft, Inc.

Green, Karl F., B.S. in M.E. (Aero.), Experimental Test Engineer, Wright Aero. Corp.

Hartswick, John A., Engineering Draftsman "B," Northrop Aircraft, Inc.

Hatalsky, William, B.Ae.E., Jr. Engineer "B," Control Surfaces Group, Boeing Airplane Co. (Seattle).

Hatch, James E., B.Ae.E., Aero. Research Scientist P-3, N.A.C.A. (Cleveland).

Hed, John Richard, B.S., Aircraft Maintenance Officer, 179th Fighter Squadron, National Guard Bureau, U.S. Air Force Sect. (Duluth, Minn.).

Hemenover, Albert D., A.A. in Ae.E., Aero. Engineer P-1, Ames Aero. Lab., N.A.C.A.

Hill, Warren D., Engineer "B," Boeing Airplane Co. (Seattle).

Hipps, Robert O., B.S., Jr. Engineer, Aeroproducts Div., General Motors Corp.

Holbrook, Charles T., B.S. in A.E., Instructor in Aero. Dept., Mississippi State College.

Howland, Robert A., M.S.E. (Aero.), Aerodynamicist, Bell Aircraft Corp.

Hurley, William J., Jr., B.S. (Aero.), Jr. Test Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Jones, Robert G., Mathematician "B," North American Aviation, Inc.

Kephart, Clair R., Standards Engineer, Piasecki Helicopter Corp.

King, Gayle Charles.

Kintis, Dino H., B.S. in Ae.E., Aero. Lab. Instructor, Tri-State College.

Kluge, Harvey Frank, Design Engineer, Goodyear Aircraft Corp.

Kohart, Harold R., B.S. Ae.E., Sr. Draftsman, Goodyear Aircraft Corp.

Korczyk, Raymond Joseph.

Lane, Frank, M.S., Asst. Prof. of Engineering Research, Ordnance Research Lab., The Pennsylvania State College.

Leland, Paul M., B.Ae.E., Instructor, Wind Tunnel Lab.; Graduate Student, Aero. Engineering Dept., University of Minnesota.

Luck, Edward John, B. of Ae.E., Aero. Engineer (Structures) P-2, U.S. Naval Air Development Station (Johnsville, Pa.).

Lyon, Herbert A., B. of Ae.E., Capt., U.S.A.F.; Project Officer, Aircraft Branch, Proof Test Div., Eglin Air Force Base.

Marshall, Robert R., B.S. Ae.E., Instructor, General Chemistry & Physics, Indiana Technical College.

McAfee, Robert E., B.S. in Ae.E., Detail Draftsman, Bendix Products Div., Bendix Aviation Corp.

McCormick, Barnes W., Jr., B.S. in Ae.E., Fellow, Ordnance Research Lab., The Pennsylvania State College.

Moore, Roland H., A.A. in Ae.E., Stress Analyst, Goodyear Aircraft Corp.

O'Donnell, Frank H., Asst. Aerodynamic Development Engineer P-1, Air Materiel Command, Wright-Patterson Air Force Base.

Parsons, Quentin E., B. of Ae.E., Design Engineer, Power Plant Installation Group, Airplane Div., Curtiss-Wright Corp.

Perry, John Wilson, B.S.E. (Aero.), Graduate Student, University of Michigan.

Pipes, Edward J., B. of Ae.E., Aero. Engineer P-1, Analytical Branch, U.S. Naval Air Development Station (Johnsville, Pa.).

Pyzdrowski, Henry A., B.S. in C.E., Design Engineer, Bend Iron Works (Oregon).

Rolland, George J., Mathematician "B," North American Aviation, Inc.

Schneider, Kenneth L., B.S. in Ae.E., Engineer "B," Boeing Airplane Co. (Seattle).

Seroy, Martin, B. of Ae.E., Jr. Aero. Engineer, Chase Aircraft Co., Inc.

Shafer, Daniel E., B. of Ae.E.

Sheeren, Melvin L., B.S., Aero. Engineer, Flight Test Unit, N.A.C.A. (Muroc).

Smith, Robert McCallister, B.S. in Ae.E.

Snyder, Roy E., Template Maker, Northrop Aircraft, Inc.

Steele, John F., B.S. in Ae.E., Stress Analyst, Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Tejral, Robert, A.A. in Ae.E., Jr. Stress Analyst, Goodyear Aircraft Corp.

Todaro, Juan, A.A. in Ae.E.

Turner, Robert B., Engineering Draftsman "B," Northrop Aircraft, Inc.

Wells, Dorson S.

Wieder, John Louis, B.S. in Ae.E., Jr. Engineer, Detail Drafting, Boeing Airplane Co. (Seattle).

Wittliff, Charles E., B.S.E. (Aero.), Graduate Student and Teaching Fellow, University of Michigan.

Aeronautical Reviews

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over which spray entered the propellers during take-off was considerably greater with the length-beam ratio of 15 than with the length beam ratio of 6. In both cases, however, the amount of spray entering was acceptable. The hull with high length-beam ratio showed less violent behavior during take-off and was less likely to reach a dangerous attitude than the hull with the low length-beam ratio.

Wave Contours in the Wake of a 10-Degree Deadrise Planing Surface. B. V. Korvin-Kroukovsky, Daniel Savitsky, and William F. Lehman. (*Stevens Institute of Technology, Experimental Towing Tank, Report No. 344.*) *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Preprint No. 170,* November, 1948. 50 pp., figs. 3 references. $1.60.

The shape of the wake formation behind a prismatic planing surface at various forward speeds and loadings, with trims of 4°, 8°, and 12°. Measurements of the water displaced relative to level water were made, and data were presented for transverse and longitudinal sections through the wake for each test run. The longitudinal contours in the wake taken along the planing surface centerline indicated a consistent variation with trim, speed, and aspect ratio. These contours are presented in a form that enables seaplane designers to estimate readily the contact area between the forebody wake and afterbody bottom for a range of pertinent conditions. The general shape and features of the wake of a 10° and 20° deadrise planing surface are basically similar. A reduction in deadrise angle, however, slightly reduces the height of the centerline profile but does not materially affect the relations between change in wave height and change in aspect ratio or load coefficient.

Wind Tunnels (17)

Constant Temperature Operation of the Hot-Wire Anemometer at High Frequency. Eli Ossofsky. *Review of Scientific Instruments,* Vol. 19, No. 12, December, 1948, pp. 881–889, diagrs., figs. 13 references.

Constant-temperature hot-wire anemometers can measure velocity fluctuations at frequencies of 30,000 cycles per sec., because the readjustment of heat balance is independent of the time constant of the wire. By considering the entire instrument as a feedback amplifier, stability criteria are established from which the amplifier frequency range and the thermal-noise-to-signal ratio are calculated for instruments with useful frequency ranges of 17,000 to 170,000 cycles per sec. The thermal-noise level of the constant-temperature instrument is five times that of a comparable constant-current instrument, because of the wider amplifier bandwidth that it requires for stable operation.

Personnel Opportunities

This Section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute

WANTED

Structures Engineer, Senior—For advanced problems in load criteria, design, and analysis. Inquiry should include comprehensive experience résumé. Address: Manager, Engineering Personnel, Bell Aircraft Corporation, P.O. Box 1, Buffalo 5, N.Y.

Top Flight Rocket Engineer—Familiar with acid-gasoline motors, to act as project engineer and coordinate the activities of staff engineers responsible for the design of various individual rocket motor components and the coordination and assembly of these components into a completed rocket motor. Address replies to: Mr. David Gregg, Administrative Engineer, Rocket Department, Curtiss-Wright Corporation, Propeller Division, Caldwell, N.J.

Electrical (Electronics) Engineers—Project Engineers, Designers, recent graduates. **Mechanical and Electromechanical Designers**—Minimum, 3 years' experience. **Layout Draftsmen (Electrical)**—Minimum, 3 years' experience design and layout electronic chassis. **Layout Draftsmen (Mechanical)**—Minimum, 3 years' experience design and layout small mechanisms, automatic machinery, etc. **Aerodynamicist (Aeronautical Engineer)**—Recent graduate or experienced. Mechanical engineering ability helpful. **Electrical (Electronics) Production and Manufacturing Engineers**—For supervisory manufacturing and production positions. Actual electronic production supervision experience essential. **Field Service Men, Electronic-Electromechanical**—Aviation background desirable. Recent graduates or experienced men. Will be trained at plant for field work. Single men preferred. Liberal expense and travel allowances. **Writers, Artists, Parts Catalog Compilers**—Technical publications. Experience essential, preferably on Government manuals covering electronic devices. **Inspectors, Electrical and Electronic**—Qualified in establishing electronic inspection procedures. Experience essential. These men needed immediately for interesting and permanent positions on an experimental, development, and production program of complex electronic and electromechanical equipment. Work covers computers, servos, amplifiers, instrumentation, small mechanisms in aircraft simulation for complex training equipment. Applicants should have college degree, equivalent experience, or both. Interviews will be arranged. Write Personnel Manager, Link Aviation, Binghamton, N.Y.; specify particular opening, qualifications, and salary expected.

Instrumentation Engineers—The Flight Test Division of the Naval Air Test Center, Patuxent River, Md., has the following vacancies: Electrical Engineer, P-4, $5,232; Mechanical Engineer P-4, $5,232; Mechanical Engineer P-3, $4,479.60, Electrical Engineer P-2, $3,727.20; Engineering Aide, Electrical SP-8, $3,727.20; Engineering Aide, Mechanical SP-8, $3,727.20. Assignments include strain-gage instrumentation, special flight installations, instrument developments, evaluations, and studies. Fill out Civil Service Application Form 57, obtainable at local post offices, and forward to: Industrial Relations Division, Naval Air Station, Patuxent River, Md.

Aeronautical Engineer—The Naval Air Test Center has an opening for an aeronautical engineer, power-plant specialist, to present courses of instruction on a college level in power-plant operation and installation and to do development work in the field of flight testing. Any applicant for this position should have at least a Bachelor's Degree in aeronautical engineering plus several years of teaching and/or industrial experience. Depending on the qualifications of the applicant, the position is either a civil service P-4 or P-5 paying from $5,232 to $6,235 per annum. Adequate low-cost Government housing for the man selected and his family is available immediately. All letters should be accompanied by completed copy of civil-service application form 57 obtainable from your local post office. Letters of application for this position should be addressed to: Director, Test Pilot Training Division, Naval Air Test Center, Patuxent River, Md.

Rocket Designer—Position available for graduate engineer experienced in development of rocket motor and missile launching equipment. Salary open. Personnel Office, Hughes Aircraft Company, Florence Ave. at Teale St., Culver City, Calif.

Industrial Engineer—U.S. Civil Service Grade P-5, starting salary $6,235.20 per year. *Basic Requirements:* A graduate engineer, experienced in methods, cost control, and budgeting work. Will be expected to initiate studies and work with cognizant department heads toward more efficient use of research and development and support funds through improvement of organization and improved use of man power. Will initiate and supervise maintenance of work measurement and progress record programs. Applications for the above position should be filed with the Executive Secretary, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

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Aeronautical Engineers—Fairchild Aircraft Division, Hagerstown, Md., has vacancies in its Engineering Department at Hagerstown and also branch engineering office, Washington, D.C., for engineering draftsman, layout engineers, aerodynamicists, electrical engineers, structures, and research engineers (with Ph.D. in Math or Physics). For immediate details write Employment Manager, Fairchild Aircraft Division, Hagerstown, Md.

969. Professor of Aerodynamics—To handle senior and graduate work in aerodynamics. Should have outstanding theoretical ability plus practical wind-tunnel experience in both subsonic and supersonic speeds. Position with one of the Big Nine Midwest Universities. Advanced degrees necessary.

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961. Development Engineer—Newly formed and rapidly expanding aeronautical instrument company located in New York Metropolitan area is seeking an instrument development engineer who is an electronics and servomechanism specialist to become Chief Engineer. Desired background will be well balanced in all phases of aeronautical instrument business, including knowledge of laboratory and shop practice from first-hand experience. An interesting salary and bonus arrangement is available to the proper person.

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971. Aeronautical Engineer—Age 31; married. Twelve years in Aeronautical Engineering. Five years as Project Engineer, exercising executive authority in directing personnel, making customer contacts, supervising specification writing, and in correspondence details. Accustomed to assuming complete responsibility in design and supervision in construction.

970. Manufacturers Representative—Aeronautical Engineer, M.S., Ae.E., California Institute of Technology; 18 years' experience in the Naval Aeronautical Organization. Technical, operational, and administrative, including 2½ years in the Bureau of Aeronautics and over 3 years in the Office of Chief of Naval Operations. Familiar with Government contract procedures, specifications, and requirements. Retired in 1947, with senior naval rank, at age of 45, and living in Washington, D.C., area. Desires to

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966. Aeronautical Engineer—College graduate and certified professional engineer (Aeronautical) with 20 years' background. Supervision, engineering, and administration in connection with aerodynamics, flight test and operations, preliminary aircraft and power plant installation design, and weight control. Desires a position as chief engineer or chief design engineer in a small aircraft company developing highly competitive commercial aircraft, or with an air line in connection with passenger or air-freight business. Complete outline of qualifications will be furnished on request.

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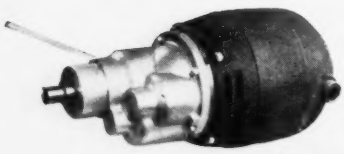

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957. Production Engineer—B.A.E., 1941. Familiar with aircraft design, stress, research problems, and fabrication methods. Broad engineering background and education, with emphasis on production and production management. Proved capable of assuming responsibility, coordinating activities of groups at various levels. Currently employed. Desires position on production staff of manufacturing organization.

956. Assistant Professor of Aeronautics—In prominent far western University; now teaching descriptive geometry, aircraft detail design, basic structures, strength of materials, and structures laboratory; desires similar position September 1, 1949. B.S. in Mechanical Engineering; 20 years' aircraft engineering experience; 2 years' fulltime teaching; author of well-known text on aircraft detail design.

955. Aeronautical Engineer — Lawyer — B.Aero.E. degree, 1942; L.L.B. degree, 1949. Age 27; married, one child. Seven years' progressive experience in structural and flight-test research. Project engineer on flight research projects involving high Mach Number. Free flight of models utilizing automatic control and telemetering. Conducted analytical investigation of autopilot requirements for high-speed aircraft. Extensive laboratory experience on all nature of static, dynamic, and flight tests. One and one-half years' part-time experience in Patent Law. Desires position utilizing engineering and legal background. I.A.S. Section officer for 2 years.

954. Project Engineer—M.I.T. Aeronautical Graduate. Eight and one-half years' experience with well-known aircraft company and research laboratory. Past 3 years as research project engineer on guided-missile program. Well-rounded background as supervisor in physics, flight test, aerodynamics, and wind tunnel sections. Capable of responsibility for technical, administrative, and customer-contact phases on aeronautical projects. Desires position with progressive organization conducting research and development on aeronautical tasks. Age 30; married; available immediately.

953. Aeronautical Engineer—B. Aero. E., 1940. Wishes supervisory position in Engineering Department in foreign country. Is facile in learning languages. Nine years' experience with three major aircraft companies as Junior Inspector, Draftsman, Senior Draftsman, Designer, Group Leader, Checker, Assistant Chief Checker. Experienced in analysis of drawings and designs in sheet metal or solid stock for clearness of presentation, practicality of design, ease of manufacture. Has done original writing and compilation for Design Section of Drafting Room Manual. Presently on loan to Engineering Test Laboratory because of electronic background.

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951. Aeronautical Engineer—M.S.; age 44. Twenty-three years' experience in aviation. Thirteen years' experience as Chief Design Engineer; was responsible for 25 different types of trainer, touring, transport, and military planes. Experienced in stress analysis and aerodynamics, including performance stability and performance tests. Familiar with British Airworthiness Requirements and Civil Aeronautics Administration Regulations. Eight years' experience as organizer, supervisor, consultant, and chief engineer of a newly built airplane factory. Thirteen years experience as performance test pilot. Twenty years' teaching on Applied Aerodynamics and Airplane Design, including some wind-tunnel operations. Desires position as engineer in airplane design or research.

950. Administrative Assistant or Industrial Engineer—B.S. Aero. E., B.S.M.E., 1945; M.S. in Management in February, 1950. Age 23. One year's experience as Administrative Assistant in charge of Engineering Planning and Control, including job breakdowns, status reports, etc. Two years as Mechanical Engineer, including design work, test programs, progress report writing, shop liaison, etc.

949. Aeronautical & Mechanical Engineer—B. Aero. E. Registered M.E. (California); 2 years Liberal Arts, U.C.L.A. extension courses in Business Administration. Total of 6 years' experience in research and development of structural and functional aircraft components, rocket launcher design and testing, aircraft maintenance. Technical Director of export-import firm (1 year). Age 31. Prefers position on West Coast in Research, Administrative, Service or Sales Engineering.

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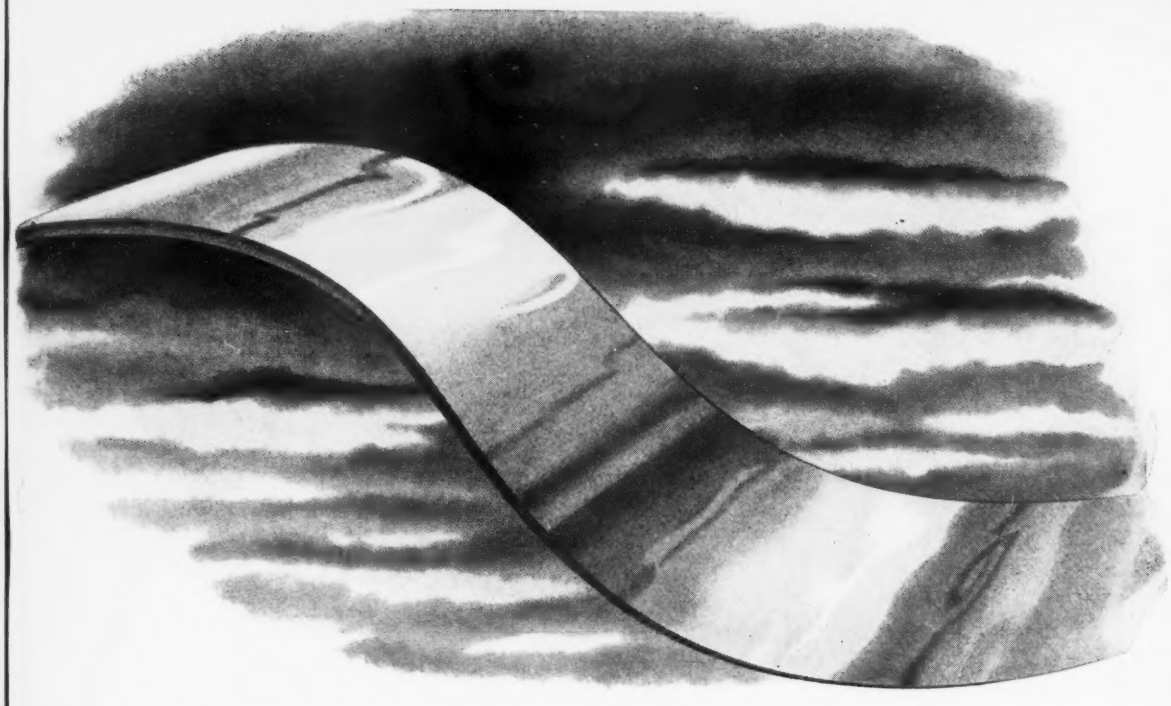

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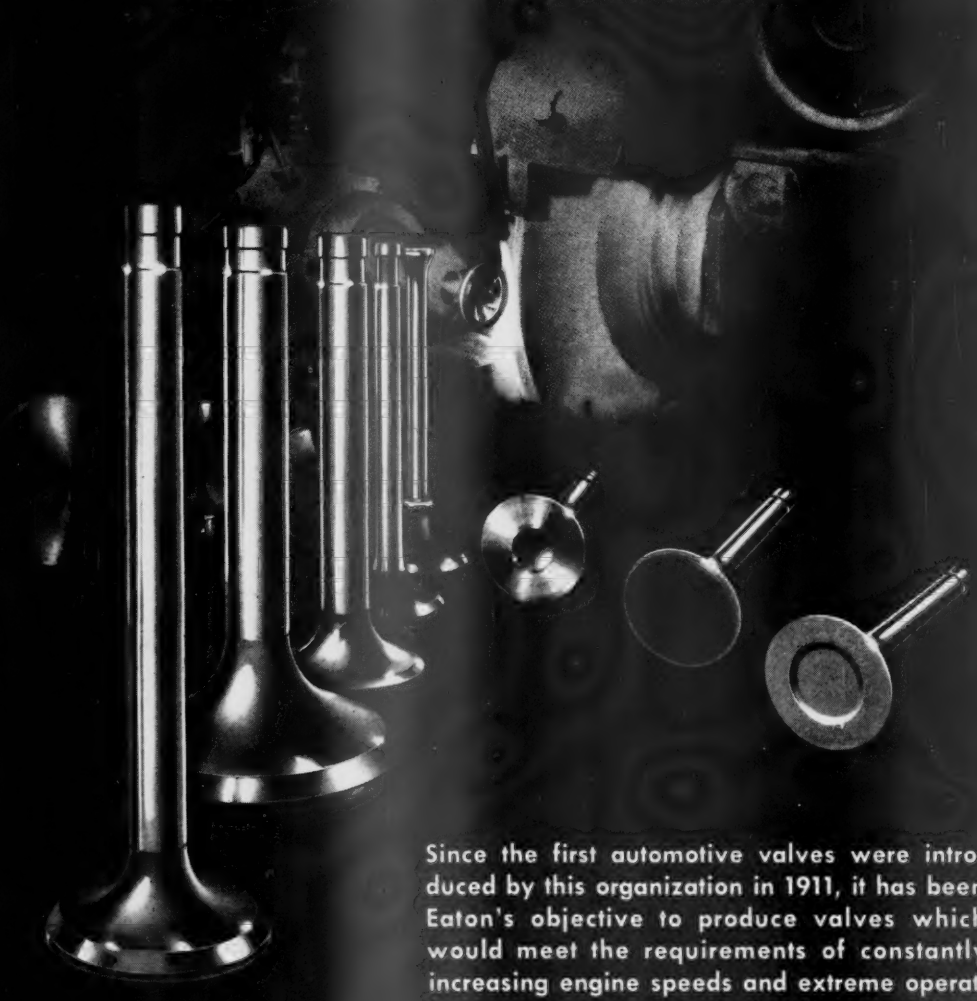
EATON VALVE DEVELOPMENT has Contributed to Higher Efficiency and Longer Life for Engines in Every Type of Service



Since the first automotive valves were introduced by this organization in 1911, it has been Eaton's objective to produce valves which would meet the requirements of constantly increasing engine speeds and extreme operating temperatures. Eaton's development of the sodium cooled valve in 1923 represents one of the most important single advancements in the history of aviation. Applying the sodium cooled principle to automotive use, Eaton is contributing thousands of miles of additional life to valves in heavy duty truck and bus service. Equally important advancements have been made in valves for passenger car use—valves which deliver a hundred thousand miles and more of dependable service.

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